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Innovation barriers across firms and countries

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Abstract

This paper studies differences in the perception of innovation barriers between innovative and non-innovative firms for 18 EU countries. The countries are grouped by their distance to the technological frontier using Community Innovation Surveys for the years 2002-2004 and 2004-2006. The results show that non-innovators interested in innovation are much more likely to perceive barriers than non-innovators that are not interested in innovation activities.

With regard to differences between country groups there is a clear indication that innovation barriers related to the availability of skilled labour, innovation partners and knowledge are more important for firms located in countries close to the frontier, while the opposite is true regarding the availability of external finance. Although the share of innovators decreases with the distance to the technological frontier, the share of barrier-related innovators increases. The results demonstrate the usefulness of the innovation barrier approach to understand the determinants of innovative activity at the firm level and to priority-setting within innovation policies.

Keywords: Innovation barriers, Europe, innovation policy

JEL: O31, O32, O38

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1. Introduction

Although innovation is increasingly seen as a key means of sustaining economic growth and welfare, there has been little research on whether barriers to innovation vary systematically across countries or firm types, and to what extent they hamper or deter innovative activity. Many governments implement policies geared towards providing incentives for firms to engage in or increase the intensity of their innovation activity. This places the idea of innovation barriers at the centre stage of innovation policy.¹ Gaining knowledge on firm and country characteristics that affect the intensity of the perception of innovation barriers can improve our understanding of the innovative process at the level of the firm, in turn informing any innovation policies.

Innovation studies which have so far analyzed the determinants of innovative activities at the firm level may be attributed to two different strands of research. The first, which is much larger, investigates the “drivers” or sources of innovation. Fitjar and Rodríguez-Pose (2011), building on Jensen et al. (2007), further divide this strand of the literature into the camp of “STI”-modes of innovation – science, technology and innovation – and the camp of “DUI” – doing, using and interacting – modes of innovation. The former relies primarily on the “use of scientific knowledge in the development of new technologies that form the basis of new products or processes within the firm. The DUI-mode refers to on-the-job problem-solving based on the exchange of experiences and know-how, through which firms find solutions to various problems that arise.” (Fitjar and Rodríguez-Pose, 2011, p. 3). In the first case, drivers of innovation are science, technology and innovation. In the second, they involve doing, using and interacting between the actors involved in the innovation process.

The barrier approach is different in that it looks at which factors act as barriers rather than drivers of innovation (Hadjimanolis, 2003), looking at both barriers affecting STI and DUI modes of innovation. At the firm level, barriers may arise internally, for example due to organizational routines, or externally, due to market, government or system failures. In particular, external barriers such as the lack of skills necessary to carry out innovation projects may represent the flipside of the innovation drivers, such as a skilled workforce.

Both approaches, the driver and the barrier approach, are necessary and complement each other in furthering our understanding of the innovation process at the firm level. The advantage of the barrier approach is that it allows for a more focused view on the innovation process, especially from an innovation policy perspective. The barrier approach makes it easier to identify any bottlenecks limiting innovative activity, i.e. which factors most constrain innovative activity among the myriad factors potentially affecting innovation. The drawback of the barrier approach is that, in order to add a useful analytic layer, it frequently requires detailed, survey-based evidence. This evidence is not easy to gather in a coherent framework. Probably as a result, past research did not systematically focus on the differences in innovation barrier perception across countries and across firm types – notably in regard

¹ Barriers are also referred to in the literature as obstacles or constraints.

to deterring innovation barriers, limiting the potential insights to be gained from the barrier approach to innovation.

We use two waves of the Community Innovation Survey (for the years 2004 and 2006) to study differences between 18 European countries, as well as between firm types with regard to hampering and deterring barriers to innovation. We enrich the existing literature in two ways: First, we take a closer look at the link between the perception of innovation barriers and firm (innovator) types. We provide evidence of hampering barriers to innovation for innovative firms and deterring barriers to innovation for non-innovative firms following D’Este et al., (2008, 2012). From an innovation policy perspective, which aims to increase the number of potential innovators, it is important to know which barriers are especially relevant for potential innovators. Moreover, we re-examine the findings of previous studies on the link between the perception of innovation barriers and firm characteristics such as firm size and group affiliation, extending it by building firm types according to their growth.

Second, we investigate how the link between the perception of innovation barriers and firm types varies across the 18 countries in our data set. These countries are quite different in terms of their economic and technological development. The 'distance to the frontier' approach acknowledges the specific role of 'appropriate institutions' (e.g. Aghion and Howitt, 2006) at different stages of development. We group countries by their distance to the frontier as we expect that differences in the technological and institutional environment associated with the distance to the frontier will affect the perception of barriers to innovation.

We link both levels of analysis – country and firm-level – and as a result we can indicate which barriers are most relevant for which firm type and for which country type, ranking barriers per firm type across country type.

The paper is organized as follows: The next section provides a background discussion of innovation barriers for our research. Section 3 presents the data and the method. Section 4 presents the results. Section 5 concludes the paper.

2. Innovation barriers at the firm level

Innovation activities are an important element of firm strategies, performance and survival. Both research and policy making have emphasized the role of innovation for fostering competitiveness and sustainable development. Nevertheless, the evidence in table 1 shows that, even in the most advanced countries of the EU, the majority of firms do not engage in innovation activities.² This raises the question of whether barriers to innovation deter potential innovators from taking up innovation activities and, if so, which ones matter. Moreover, as shown by the results from the Community Innovation Survey, innovation intensity as measured, for example, by the share of turnover achieved with innovative products, varies widely among innovative firms. This raises the question of whether barriers to innovation hamper already innovative firms in their efforts to increase innovative activity.

² As this evidence is based on Community Innovation Survey Data, it is likely to overestimate the share of innovators. Microenterprises (below 10 employees) are not included in the CIS. Microenterprises have a lower propensity to innovate and make up the largest share of firms in all European economies (e.g. Hölzl and Reinstaller, 2009).

Potential failures to engage in innovative activity or to expand innovative activities may be related to external or internal barriers to innovation.

Table 1: Innovators across country groups

	Full sample	Country group 1	Country group 2	Country group 3	Country group 4
Innovators	35%	45%	34%	37%	20%
R&D innovators	16%	29%	16%	17%	3%
Non-technological innovators	19%	16%	18%	20%	17%
Non-innovators	65%	55%	66%	63%	80%

Source: CIS 4 and CIS 2006 data accessed at the Eurostat safe centre. WIFO calculations. The numbers are simple averages over CIS 4 and CIS 2006 averages. See section 3.2 for details on the country groups (group 1: member states close to technological frontier - Belgium, Denmark, Germany, Finland, France, Iceland, Luxemburg, Norway, Sweden; group 2: advanced catching up member states, Czech Republic, Estonia, Hungary, Slovenia, Slovak Republic, Ireland; group 3: Southern European member states with low- to medium tech industry structure and high GDP, Spain, Italy, Portugal, Greece; group 4 : trailing catching up member states). Bulgaria, Lithuania, Latvia, Romania, Cyprus, Malta.

2.1 External and internal barriers to innovation at the firm level

Hadjimanolis (2003) distinguishes between external and internal barriers to innovation and provides a detailed classification. Many important barriers to innovation are found within the enterprise. Adopting new technologies and introducing new products and organizational structures creates resistance within the firm. While internal and external changes often stimulate innovative exploration, internal resistance to change can prevent it. Within larger and established firms many different barriers to innovation can be identified (Assink, 2006):

1. Adoption barriers are related to dominant designs, path dependency and successful products. They limit the ability to search for new disruptive innovations. Such adoption barriers are often be increased by excessive bureaucracy in large enterprises leading to a status-quo bias.
2. Mindset barriers are related to the inability to unlearn the old logic of how products and markets work. This may also be associated with the lack of distinctive competencies to detect and exploit opportunities arising from external changes.
3. Risk barriers are associated with an excessive reliance on routines and experience and an unwillingness to cannibalise own product markets. Disruptive innovations often threaten the existing products of established firms.
4. Nascent barriers are associated with management capabilities to foster thinking outside the box and the management of the innovation process.

These barriers do not necessarily imply that radical innovation cannot take place within the firm, but they indicate that existing organizations try to resist changes, which need not be negative. Not every innovation project is worth executing. Internal innovation barriers can thus also be considered organizational screening devices, which filter worthy innovation projects from unworthy ones. Tang and Yeo (2003) argue that such internal barriers may even lead to an improvement of the innovation

performance of enterprises. This shows that internal innovation barriers should be considered factors that affect the innovation process within enterprises, deterring, delaying or changing innovative ideas and innovation projects (Mirow et al, 2007). They are primarily an issue of management, organization and firm competences.

In contrast, external barriers may emerge when the firm interacts with other firms, agents or institutions in the economic and innovation system in order to carry out its innovative activities. Issues such as a lack of availability of finance for innovative activities, a lack of technological knowledge or market opportunities for innovation, a lack of connectivity in the innovation system that impedes innovative collaboration, and the availability of skilled labour are related to the institutional and market context of an economy and may thus be closely associated with market, government and system failures. This can have an impact on both STI and DUI modes of innovation.

While the evidence on internal barriers to innovation is of interest to policy makers, as it helps to understand how firms actually innovate and how internal barriers affect the innovation potential of firms, only evidence on external barriers to innovation can provide a rationale for policy intervention. The basic rationale for this view is that innovation opportunities which remain unexploited by certain firms are often taken up by other firms, potentially innovative entrepreneurs and start-ups.³ Hence our contribution focuses only on barriers to innovation external to the firm.

2.2 The perception of obstacles: deterring vs. hampering barriers to innovation

At the firm level, it is well known that firm characteristics affect the perception of external barriers to innovation. Concentrating on the perception of barriers among innovative firms or treating non-innovative firms as an undifferentiated group, Arundel (1997), Mohnen and Rosa (2002), Baldwin and Lin (2002), Galia and Legros (2004), Mohnen and Röller (2005) and Iammarino et al. (2009), Hölzl and Friesenbichler (2010) find that innovative firms attach higher importance to innovation barriers than do non-innovators. Within the group of innovating firms, the obstacles were considered more relevant by firms featuring high innovation and R&D intensities. Therefore, in the existing empirical literature the answers to survey questions on innovation barriers are generally considered as (innovative) firms' assessment of the obstacles and as a measure of their ability to overcome them. Baldwin and Lin (2002) and Galia and Legros (2004) provide two possible complementary interpretations:

1. Performing innovation activities increases the awareness of the difficulties encountered, without preventing firms from pursuing innovation projects.
2. The formulation of the CIS question on obstacles leads firms to assess the problems they faced and have overcome in performing innovation activities.

Although barriers interpreted in such a way resemble drivers of innovation, as their occurrence is associated with innovative activity, existing empirical research, which often focuses on financial constraints, finds a negative impact of hampering barriers on innovative activity in terms of delaying,

³ This shows that there is a close relationship between entrepreneurship policy and innovation policy. In fact, the promotion of high-technology entrepreneurship and early stage venture capital is an important element of innovation policy today.

abandoning or not initiating innovative projects (Canepa and Stoneman, 2008, for English firms). For French firms, Galia and Legros (2004) find that those firms which abandon projects tend to be more subject to economic barriers (costs, risks and customer responsiveness) than to technological or organizational ones. For Dutch firms, Mohnen et al. (2008) find that financial constraints tend to impede the initiation of projects, while skill and knowledge barriers slow down innovative projects. Overall, barriers have had a significantly negative impact on innovative activity by Dutch firms. Criscuolo et al. (2010) examine Finnish firms in CIS3 and CIS 4, concluding that hampering barriers to innovation are negatively correlated with sales from innovative products. This suggests that innovating is difficult for firms, because of the cost, knowledge and market factors involved.

While available empirical evidence suggests that non-innovative firms are less affected by innovation barriers than innovative firms, little is known about the role barriers play in the take-up of innovation by non-innovative firms. The existing literature on barriers to innovation usually does not address this central policy question, namely whether and which barriers to innovation are crucial in inhibiting the take-up of innovation activities by non-innovators.

Among the exceptions are Mohnen and Röller (2005) who examine complementarities between innovation policies using CIS data for four European countries. They find that different sets of policies are necessary in order to foster the propensity to innovate and innovation intensity. However, they do not differentiate between barrier-related and non-barrier-related non-innovators, and find as a consequence that barriers are more frequent among innovative firms.

Savignac (2008) uses a French firm survey based on the CIS methodology to examine the impact of financial innovation barriers on innovative activity. She finds that, when controlling for the endogeneity of financial constraints and distinguishing between non-innovative firms seeking to innovate and those not seeking to innovate, the probability of carrying out innovative activity is significantly reduced by the existence of financial constraints for French manufacturing firms. Hence, Savignac (2008) is among the first to find that barriers matter for non-innovative firms when the subset of firms interested in innovation is taken. Using CIS data for the UK, D'Este et al. (2008, 2012) are able to show that non-innovators that have little interest in performing innovation activities rank innovation obstacles as having low importance. However, non-innovative firms aspiring to be innovative experience barriers in the same way that innovative firms do, once again rejecting the findings of the previous literature that suggest innovative firms are more likely to report barriers to innovation. They distinguish between hampering barriers to innovation and deterring barriers. The first are barriers that obstruct firms' achievement in innovation activities, while the second type of barrier prevents firms from engaging in innovation activities.

In this paper we follow D'Este et al. (2008, 2012), studying the perception of innovation barriers across two groups of non-innovators. We differ from D'Este et al. (2008, 2012) by using a different method to identify barrier-related non-innovators based on the answers to the questions on barriers to innovation as collected in CIS 4 and CIS 2006. At the same time we extend the research by D'Este et al. (2008, 2012) and Savignac (2008) by considering a large number of European countries (18) and using an expanded set of control variables that offers more detail on those factors affecting the perception of barriers to innovation, e.g. as regards firm growth and the distance to the technological

frontier. By distinguishing barrier-related and non-barrier-related non-innovative firms we provide a rich picture of the barriers to innovation and their importance across firms and countries.

2.3 Factors affecting the perception of innovation barriers: firm and sector types

In our study we control for a number of firm and sector characteristics. We control for the innovation intensity of firms by using different innovator types (see section 3.3). In addition, based on the economic literature on innovation, we expect the following factors to affect the perception of deterring and/or hampering barriers to innovation.

2.3.1 Firm size

Firm size is generally considered an important factor in explaining firms' innovation behaviour (e.g. Cohen and Klepper, 1996). The fact that larger firms are able to draw on an internal pool of resources and that innovative activities have some aspect of fixed costs or indivisibilities leads us to expect larger firms to be less vulnerable to hampering barriers to innovation, as shown, for example, by Canepa and Stoneman (2008), or Mohnen and Röller (2005). Moreover, large non-innovative firms are likely to be non-innovative by choice, while barriers may deter small firms from taking up innovation activities.

2.3.2 Firm growth

Given the fact that entrepreneurial high-growth firms play an important role in radical innovation (Baumol, 2008) and net employment generation, as well as the diffusion of technology, it is surprising that we do not know more about the significance of innovation barriers to them (e.g. Henrekson and Johansson, 2009, Coad and Hözl, 2012). In fact, Hözl (2009) and Coad and Rao (2008) document that R&D and innovation are important determinants of high growth in advanced countries. Although high growth firms may perceive lower barriers to innovation because they are more successful than average growth firms, we expect high growth performance to affect the perception of innovation barriers positively, because such firms made much more effort to overcome the obstacles and because firm growth requires new financial, human and knowledge resources. On the flipside, we expect those firms featuring very low growth rates to be less likely to experience obstacles to innovation.

2.3.3 International and national linkages of firm activities

It is generally thought that it is easier for firms to access knowledge and human and financial resources within their own organization than outside it. Technological activity in multi-location firms is organized in networks that allow for the strategic integration of different knowledge bases. Hence, being part of a domestic corporate group should reduce the perception of barriers. On average, multinationals tend to be larger, have a higher level and variety of accumulated competence and be more research-intensive than purely domestic firms (Iammarino et al. 2009), further reducing the perception of barriers. The effect of internationalization (in the form of exports) on the perception of innovation barriers is more difficult to hypothesize. The evidence that internationalized firms are subject to competitive pressure from foreign firms leads us to suspect that exporting firms are more

aware of technological knowledge gaps than firms that only operate domestically. Seen from the resource angle, exporting is demanding in terms of efforts. Gorodnichenko and Schnitzer (2010) find that being innovative and exporting at the same time financially constrains firms located in catching-up countries.

2.3.4 Sectoral innovation intensities

Barrier studies examining variables which affect the perception of barriers usually find that firms in sectors with higher innovation intensity are more likely to experience barriers (e.g. Canepa and Stoneman, 2008).

2.4 Factors affecting the perception of innovation barriers: Distance to the frontier

In this paper we implicitly apply the technology frontier concept at the country level. This approach emphasizes that the effectiveness of economic policies and firms' competitive strategies is conditional on a country's distance to the world technological frontier (e.g. Aghion and Howitt, 2006). Using a stylised model, Acemoglu et al. (2006) show that highly skilled personnel and technology-intensive firms are more important for economic growth in countries close to the technological frontier than in those further away from the frontier. A firm's perception of innovation barriers is likely to be affected by or associated with the distance to the frontier. A firm close to frontier is more likely to strive for innovation-based competitive advantage, based on research and own creation of knowledge. As a result, it will perceive different barriers than a firm far from frontier which is more likely to pursue competitive strategies based on absorbing existing technologies. Requirements of different sets of firm capabilities are likely to be reflected in the perception of barriers to innovation. At the same time, the innovation support systems' impact on a firm's barrier perception will also be affected by the overall distance of the country from the frontier. Initially, we have a question of inertia: Do innovation support systems move along, shifting the focus from absorbing technology to creating knowledge, as firms advance? And, second, looking at the relationship from the other side: How do sophisticated innovation support systems affect firms' perception of barriers, for example with regard to financial constraints and skill barriers?

3. Data and Methodology

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 two years in all EU member states, as well as several non-EU countries (e.g. Norway, Iceland).⁴ The CIS aims to provide a sound source of statistical data on innovation by using a stratified sample of companies. CIS data are increasingly used as a key data source in the study of innovation at the firm

⁴ 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.

level in Europe, Canada and Australia. Mairesse and 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.

Table 2: Country classification and data availability

Country group 1	Country group 2	Country group 3	Country group 4
<i>High direct technology intensity</i>	<i>High indirect technology intensity</i>	<i>Low direct and indirect technology intensity, with higher GDP per capita</i>	<i>Low overall technology intensity</i>
Belgium (BE)§ Denmark (DK)++,+++ Germany (DE)§ Finland (FI)++,+++ France (FR)++ Iceland (IS)++ Luxembourg (LU)++,+++ Norway (NO)++,+++ Sweden (SE)++,+++ United Kingdom (UK)§ Netherlands (NL)§ Austria (AT)§	Czech Republic (CZ)++,+++ Estonia (EE)++,+++ Hungary (HU)++,+++ Slovenia (SI)++,+++ Slovak Republic (SK)++,+++ Ireland (IE)+++	Spain (ES)++,+++ Italy (IT)++,+++ Portugal (PT)++,+++ Greece (GR)++,+++	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 Luxembourg: ++ CIS 4, +++ CIS 2006; § access not allowed by national statistical institute.

3.2 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 and 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 capacity 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 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. Finally, the fourth group, consists of countries with *low overall technology intensity*, both in terms of direct and indirect R&D as well as low GDP per capita. Table 2 presents the classification of countries and indicates for which countries CIS data could be accessed at the Eurostat Safe Centre in Luxembourg.

3.3 Innovator types

3.3.1 Innovators

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: R&D innovators and non-technological innovators. R&D innovators are the subset of innovative firms which perform own R&D, and the set of innovators that do not perform own R&D is called non-technological innovators. This distinction is based on 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 analysing barriers to innovation. We expect R&D innovators to have a different perception of obstacles to innovation than non-technological innovators.

3.3.2 Non-innovators: Procedure to identify barrier-related non-innovators

The distinction between the different groups of non-innovators is crucial for the present study. The questions used by D'Este et al. (2008, 2012) to distinguish between different types of innovators are unique to the UK CIS 4. They are not available for the CIS 4 and CIS 2006 in our harmonized sample across 18 countries. We will therefore use a different approach to separate innovation-interested from non-interested non-innovators. We assume that non-barrier-related non-innovators are firms that do not aspire to perform innovation activities, i.e. that barriers are not the reason for their lack of innovation. As a starting point, we identify barrier-related and non-barrier-related non-innovators based on the importance they afford to specific barriers listed in the question "During the years 2002/4 to 2004/6, how important were the following factors for hampering your innovation activities or projects or influencing a decision not to innovate" in the CIS 4/CIS 2006.

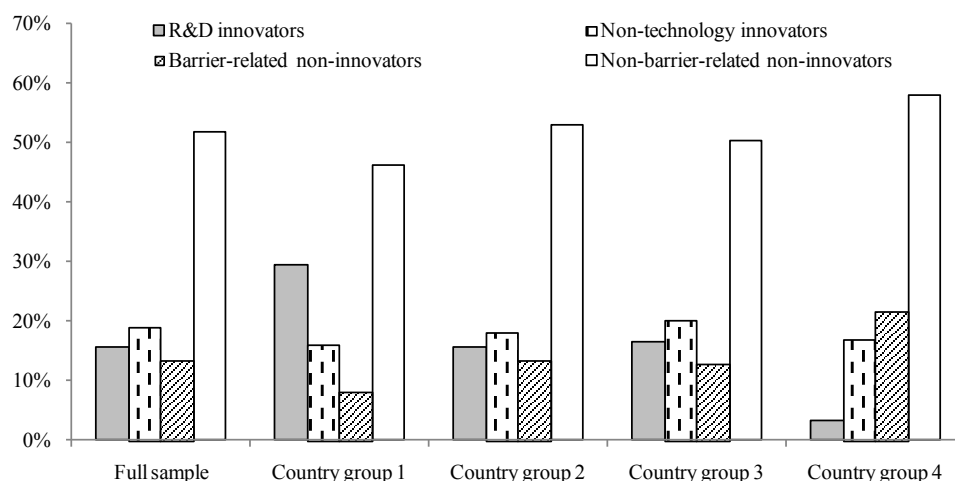
We define an indicator for the intensity of barrier perception for each firm (innovators and non-innovators), which we define as an average over the 9 different answers on the barriers (3=high, 2=medium, 1=low, 0=not experienced). In order to control for the variety of answers to the questions on hampering barriers across sectors and countries, we subtract sector-country averages from the barrier indicator at the firm level. Answers may be influenced by unknown cultural, linguistic or sector-specific phenomena.

In addition, we give those firms which show a higher variety of answers a higher weight by multiplying our indicator of barrier perception by 1 plus the standard deviation of answers to the 9 questions at the firm-level. This weighs down firms which put the same answer everywhere to save time in filling out the questionnaire, rather than attempting a balanced assessment of barriers encountered. Indeed, Mohnen and Röller (2005) document that, in their CIS sample comprising firms from four European countries, the case where firms either only report 0 – no barrier experienced – or 3 – every barrier is of high importance – is most frequent.

Finally, we calculate the average of the indicator for the intensity of barrier perception over the whole sample. We define as barrier-related innovators those non-innovating firms which 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.

Figure 1: Distribution of innovator types across country groups



Source: CIS 4 and CIS 2006 data accessed at Eurostat Safe Centre; WIFO calculations. Values are averages over CIS 4 and CIS 2006 aggregates.

Figure 1 presents the distribution of the types of innovators (R&D innovators, non-technological innovators) and non-innovators (barrier-related and non-barrier-related non-innovators) across the country groups. Non-barrier-related non-innovators constitute the largest group in all country groups. This supports our distinction, as the usual finding of barriers not being relevant for non-innovators can only arise when non-interested innovators dominate over interested innovators. Country group 1 has the lowest number, followed by country groups 2 and 3. Country group 4 has the highest number of non-barrier-related non-innovators. The opposite is true for R&D innovators. The distribution of non-technology innovators is much more similar across the country groups. In contrast, the distribution of barrier-related non-innovators across country groups is quite unequal. Most barrier-related non-innovators are found in country group 4 followed by country groups 2 and 3. Country group 1 has the lowest share of barrier-related non-innovators. However, in all country groups, barrier-related non-innovators represent a sizeable share of firms.

3.4 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 four-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 to be 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 for whether firms find the barrier to be important or not.⁵

⁵) Canepa and Stoneman (2008) do the same in their research of financing constraints. By reducing the informational content of the dependent variable – we do not differentiate between high and medium on the one hand and low and not relevant on the other hand – we can use linear probability models instead of ordered models that would take into account all four characteristics of the original variables. Early results have shown that ordered probit failed to converge in a number of specifications and that for those specifications which converged, no substantial qualitative differences with regard to the interpretation of our results emerged.

Table 3: Importance of selected barriers to innovation for all firms and innovators across country groups (Share of firms reporting medium or high barriers to innovation)

	All	Country group 1	Country group 2	Country group 3	Country group 4
All firms					
Financial barriers	33%	19%	28%	38%	42%
Skill barriers	36%	34%	29%	37%	39%
Lack of information on technology	28%	19%	18%	33%	30%
Lack of information on markets	27%	20%	19%	29%	28%
Lack of innovation partners	25%	19%	20%	27%	33%
R&D innovators					
Financial barriers	44%	30%	38%	55%	55%
Skill barriers	47%	49%	47%	45%	54%
Lack of information on technology	33%	28%	25%	37%	35%
Lack of information on markets	33%	31%	28%	34%	35%
Lack of innovation partners	32%	28%	25%	37%	37%
Non-technological innovators					
Financial barriers	38%	19%	30%	43%	48%
Skill barriers	42%	42%	35%	42%	45%
Lack of information on technology	34%	23%	19%	38%	32%
Lack of information on markets	30%	22%	20%	32%	30%
Lack of innovation partners	26%	20%	20%	27%	36%
Barrier-related non-innovators					
Financial barriers	62%	37%	57%	69%	73%
Skill barriers	61%	59%	49%	64%	60%
Lack of information on technology	49%	33%	32%	57%	48%
Lack of information on markets	47%	33%	33%	52%	45%
Lack of innovation partners	45%	34%	37%	48%	52%
Non-barrier-related non-innovators					
Financial barriers	20%	9%	17%	22%	27%
Skill barriers	24%	17%	16%	25%	28%
Lack of information on technology	20%	10%	11%	23%	22%
Lack of information on markets	18%	9%	12%	21%	21%
Lack of innovation partners	17%	10%	14%	18%	24%

Source: CIS 4 and CIS 2006 data accessed at the Eurostat safe centre. WIFO calculations. The numbers are simple averages over CIS 4 and CIS 2006 averages. See section 3.2 for details on the country groups (group 1 : member states close to technological frontier, group 2 : advanced catching up member states, group 3 : Southern European member states with low- to medium tech industry structure and high GDP, group 4 : trailing catching up member states). Barriers are measured as binary variable. The variable takes the value of 1 if the degree of importance is judged to be medium or high. If the degree of importance is judged to be low or not relevant the variable gets the value 0. 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 3 provides descriptive evidence on differences in the perception of innovation barriers across types of innovators and country groups. From these descriptive statistics it emerges that the skill barrier is the single most mentioned barrier to innovation, followed by the lack of external financing and knowledge barriers to innovation. Across country groups, the relevance of barriers increases with technological distance. Firms in country group 1 generally report the lowest number, followed by group 2, group 3 and group 4.

Barrier-related non-innovators represent the highest share of firms reporting barriers to innovation, in particular lack of financing. This is first evidence that barriers do matter for non-innovators – namely those interested in innovation, in line with the results of D’Este et al. (2008, 2012) and Savignac (2008). It qualifies the results of the earlier literature, which did not distinguish different groups of non-innovators. R&D innovators and non-technological innovators follow. Non-barrier-related non-innovators record the lowest scores for innovation barriers. These firms are generally not deterred by barriers to innovation because they do not aspire to engage in innovation.

A lack of qualified personnel is more likely to be reported by innovative firms than a lack of financial resources in country groups 1 and 2. Financial barriers are most often reported by firms in the other country groups, especially in country group 4. The knowledge barriers related to lack of information on technology and markets, as well as difficulties in finding innovation partners, are reported more often in country groups 3 and 4 than in country groups 1 and 2. The differences between country groups are not only found at the aggregate level, but also at the level of the different subsets of firms. For example, the higher importance of skill constraints for firms in country group 1 is found for R&D innovators as well as for barrier-related and non-technological innovators. This suggests that country differences have an impact across different firm types and points to the relevance of this factor when explaining differences in the perception of innovation barriers. The overall message is that differences between firms and countries matter for the perception and experience of barriers to innovation:

1. The perception of barriers to innovation is highest for barrier-related non-innovators, and higher for innovating firms than for non-barrier-related non-innovating firms. R&D innovators perceive barriers to innovation as more important than non-technological innovators. This shows that barriers to innovation play a role as both hampering and deterring barriers for innovative firms, both limiting and preventing firms from engaging in innovative activities. While it is difficult to gauge the impact of hampering barriers on innovation intensity, as barriers may be overcome, the share of barrier-related non-innovators is a clear indication of the impact of deterring barriers on the propensity to innovate.
2. Distance to the frontier matters in the perception and experience of different innovation barriers. Firms in countries closer to the technological frontier attach more significance to a lack of skilled labour than to a lack of financing. For countries far away from the frontier the reverse is true.

To test for the significance of the results from our descriptive analysis, we will carry out an econometric analysis for the different country groups.

3.5 Variable definitions

The definition of the barriers to innovation variables, the country groups and the innovation types was presented before. As mentioned in section 2.3, for the econometric analysis we consider factors affecting the perception of innovation barriers, using the following variables:

1. *Firm size* is measured by the logarithm of employees.
2. The second set of variables is related to the growth performance of enterprises. We define high growth firms following a definition that is similar to the Eurostat-OECD (2008) definition. For each enterprise with more than 10 employees we calculate the annualized employment growth rate as follows:

$$\text{growth}_j = \sqrt[2]{\frac{\text{Employment}_{j,t+2}}{\text{Employment}_{j,t}}} - 1.$$

High growth firms are those firms whose annualized growth rate is above 20%. 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 interpret the effect of firm growth on the perception of innovation barriers.

3. We include dummy variables that identify whether the firm is part of a domestic or foreign corporate group. In addition, we include a dummy variable for internationalization via exporting into the analysis.
4. 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 in the country group regressions following the industrial classification by Peneder (2010), who distinguishes between 5 different sector groups according to their innovation intensity. We also control for basicness and cumulativeness of R&D at the industry level (see appendix C).

3.6. Estimation methodology

The primary goal of the analysis is to uncover systematic differences between different types of innovative and non-innovative firms in the perception of innovation barriers across country groups. This limits the construction of dependent variables to the questions in the CIS that are answered by all firms. Our baseline specification is the following:

$$\text{Barrier}_i = f(\text{FS}_i, \text{HG}_i, \text{STABLE}_i, \text{INTER}_i, \text{GP_fo}_i, \text{GP_do}_i, \text{INDUSTRY}, \text{COUNTRYGR}, \text{INNOTYPE})$$

FS denotes firm size, HG whether the firm is a fast-growing firm, STABLE whether the firm experienced low growth/decline and INTER whether the firm is internationalised. *GP_fo* is a dummy variable denoting that the firm is part of a foreign corporate group and *GP_do* is a dummy variable denoting that the firm is part of a domestic corporate group. INDUSTRY denotes the set of sectoral dummy variables explained above. COUNTRYGR denotes the country group dummies and, last but

not least, INNOTYPE denotes the four different types of innovators and non-innovators. In the regression the firm weights provided by Eurostat were used to correct for the different sampling of firms at the country level.

Our dependent variables (innovation barriers) are constructed as binary variables. As we are only interested 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 and Pischke (2008) argue that, if one is interested in the mean effect, $E(Y=I|X)$, 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 variable models and linear probability models. Probit and logit estimates would require the computation of marginal effects at the mean.⁶

4. Results

4.1 Innovator and firm types

Table 4 reports the results of the baseline regressions. The results are quite similar between CIS 4 and CIS 2006, suggesting that we uncover regularities in the perception of innovation barriers across firms.

With regard to innovator types, we see that R&D innovators, non-technology innovators and barrier-related non-innovators have a significantly higher propensity to assess innovation barriers as relevant than do reference type non-barrier-related non-innovators. In line with our descriptive results, barrier-related non-innovators have the highest propensity to be affected by innovation barriers (from 25% to 43% higher than non-interested non-innovators), followed by R&D innovators (from 13% to 23% higher) and non-technology innovators (5.5% to 17% higher). Across these innovator types, financial and skill barriers are most likely to be reported, followed by the three knowledge barriers technology, markets and innovation partners. This suggests that, in the pooled sample, deterring and hampering barriers are not very different in nature.

We confirm previous findings of the literature, as our results show that firm size has the expected negative influence on the perception of innovation barriers. Larger firms are less likely to perceive innovation barriers than smaller firms. Moreover, high growth firms judge innovation barriers to be higher (between 0.5% and 2.5%) than the reference group of firms featuring average growth, with the exception of lack of information on markets in CIS 2006. In contrast, stable firms are, as expected, hampered less by innovation barriers (up to 2.7%). Interestingly, export-active firms are *ceteris paribus* more likely to report innovation barriers than firms that only operate on domestic markets, indicating that simultaneously undertaking innovative activities and exporting can be demanding. In the international markets they face tighter competition from similar innovative firms. In contrast, being part of a foreign or domestic group considerably reduces the perception of innovation barriers. The effect is much stronger within a foreign group (5% to 11%) than a domestic group (0.6% to 5%),

⁶ 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.

especially in the CIS 4 sample, but less so in the CIS 2006 sample. This may be associated with the different coverage of countries in country group 1 in the CIS 2006 sample. A combination of the firm characteristics above – such as small firm size, independence, high growth and exporting - is likely to be particularly prone to experience barriers to innovation. However, innovator type – R&D innovators, non-technological innovators or barrier-related non-innovators – also plays an important role.

Table 4: Innovation barrier regressions for CIS 4 and CIS 2006, pooled sample

	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 innovators	0.2037***	0.1997***	0.1332***	0.1299***	0.1301***	0.2374***	0.2316***	0.1646***	0.1737***	0.1389***
Non-technological innovators	0.1319***	0.1580***	0.1263***	0.0931***	0.0545***	0.1604***	0.1719***	0.1273***	0.1144***	0.0767***
Barrier-related non-innovators	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.

With regard to sectoral control variables, manufacturing firms report a higher impact of obstacles to innovation than non-manufacturing firms (ranging from 3% to 10%). The dummy variables associated with the industry innovation taxonomy of Peneder (2010) show that firms in industries with high innovation intensity generally report slightly higher financial and skill barriers. These taxonomies were primarily used as control variables and should not be over-interpreted.

The results for the country groups show that, on average, firms located in country group 1 display lower innovation barriers than country group 4. This is most striking for financing barriers, which are less likely to be perceived (17% lower) as hampering innovation by firms in country group 1 than by firms in country group 4. Furthermore, for country group 2 we observe lower average perception of innovation barriers than for country group 4 (from 6% to 20% lower for the different barriers). This also holds for country group 3 for the CIS 2006, but not for the CIS 4.

Table 5: Innovation barrier regressions for country groups, CIS 4 and CIS 2006

	Financial barriers		Skill barriers		Lack of information on technology		Lack of information on markets		Lack of innovation partners	
	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006
Country group 1										
R&D innovators	0.1724***	0.1752***	0.2391***	0.3376***	0.1347***	0.1955***	0.1640***	0.2211***	0.1498***	0.1638***
Non-technological innovators	0.0912***	0.0690***	0.2207***	0.2246***	0.1441***	0.0959***	0.1267***	0.0963***	0.1041***	0.0721***
Barrier-related non-innovators	0.2614***	0.2443***	0.3834***	0.3754***	0.2350***	0.1771***	0.2695***	0.1591***	0.2523***	0.2003***
Firm size	-0.0174***	-0.0174***	-0.0156***	0.0184***	-0.0164***	-0.0096***	-0.0140***	-0.0091***	-0.0119***	-0.0135***
Fast growing firm (y/n)	0.0027	-0.0379***	0.0266***	0.0200*	-0.0005	0.0004	0.0013	-0.0139	0.0074**	0.0127
Stable firm (y/n)	-0.0138***	-0.0481***	-0.0182***	-0.0400***	-0.0164***	-0.0101*	-0.0026	-0.0240***	0.0068***	-0.0273***
Exporting firm (y/n)	0.0097***	0.0118**	-0.0360***	-0.0321***	-0.0027	-0.0162***	-0.0045**	-0.0048	0.0067***	0.0152***
Part of foreign group (y/n)	-0.0088***	-0.0226***	-0.0597***	0.0055	-0.0161***	0.0135**	-0.0260***	0.0087	-0.0410***	-0.0267***
Part of domestic group (y/n)	0.0288***	-0.0180*	-0.0157***	-0.0794***	-0.0082***	-0.0477***	-0.0010	-0.0463***	-0.0091***	-0.0368***
Manufacturing	0.0387***	0.0055	0.0329***	0.0351***	0.0393***	0.0666***	0.0446***	0.0215***	0.0267***	0.0334***
Constant	0.2763***	0.9703***	0.6494***	0.1665	0.3556***	0.7588***	0.1513***	0.6543***	0.3411***	0.7104***
Observations (weighted)	221,350	24,035	221,384	24,046	221,374	24,030	221,364	24,035	221,361	24,040
pseudo R2	0.068	0.072	0.101	0.125	0.053	0.059	0.066	0.066	0.062	0.051
ll	-99,601	-10,790	-135,513	-14,796	-104,525	-10,995	-104,490	-11,090	-99,759	-10,812
Country group 2										
R&D innovators	0.2274***	0.1693***	0.2738***	0.2729***	0.1585***	0.0903***	0.1863***	0.0990***	0.1129***	0.0683***
Non-technological innovators	0.1361***	0.1239***	0.1285***	0.1864***	0.0619***	0.0642***	0.0799***	0.0634***	0.0632***	0.0296***
Barrier-related non-innovators	0.3750***	0.3836***	0.2853***	0.3065***	0.1922***	0.1911***	0.2150***	0.1786***	0.2281***	0.2101***
Firm size	-0.0121***	-0.0064***	-0.0158***	-0.0027	-0.0125***	0.0065***	-0.0166***	0.0011	-0.0070***	0.0022
Fast growing firm (y/n)	0.0104	-0.0073	0.0284***	0.0037	0.0458***	0.0036	0.0461***	-0.0162***	0.0217***	-0.0003
Stable firm (y/n)	-0.0335***	0.0151***	-0.0248***	-0.0137***	-0.0189***	0.0014	-0.0268***	0.0056	-0.0310***	0.0092**
Exporting firm (y/n)	0.0359***	0.0375***	0.0116***	0.0210***	0.0123***	0.0146***	0.0349***	0.0141***	0.0319***	0.0178***
Part of foreign group (y/n)	-0.1268***	-0.1451***	-0.0590***	-0.0835***	-0.0473***	-0.0580***	-0.0648***	-0.0602***	-0.0745***	-0.0638***
Part of domestic group (y/n)	0.0174***	-0.0371***	0.0232***	-0.0200***	0.0413***	-0.0025	0.0169***	-0.0167***	0.0084	-0.0369***
Manufacturing	0.0371***	0.0441***	0.0566***	0.0500***	0.0563***	0.0327***	0.0563***	0.0405***	0.0330***	0.0294***
Constant	0.7891***	1.4438***	0.5206***	0.7711***	0.5780***	0.6534***	0.4350***	0.6205***	0.6759***	0.7171***
Observations (weighted)	65,508	55,927	65,535	55,927	65,508	55,927	65,513	55,927	65,524	55,927
pseudo R2	0.121	0.118	0.086	0.091	0.052	0.041	0.064	0.039	0.057	0.044
ll	-36,225	-31,380	-37,582	-33,187	-29,197	-23,985	-30,600	-24,508	-31,369	-26,652
Country group 3										
R&D innovators	0.2166***	0.3169***	0.1576***	0.1909***	0.1218***	0.1579***	0.0851***	0.1605***	0.1101***	0.1797***
Non-technological innovators	0.1454***	0.1877***	0.1304***	0.1724***	0.1260***	0.1508***	0.0743***	0.1298***	0.0275***	0.0881***
Barrier-related non-innovators	0.3739***	0.4681***	0.3089***	0.3939***	0.2912***	0.3512***	0.2466***	0.3390***	0.2707***	0.2851***
Firm size	-0.0157***	-0.0097***	-0.0033***	-0.0052***	-0.0023***	-0.0088***	0.0027***	-0.0100***	-0.0042***	-0.0020*
Fast growing firm (y/n)	0.0125***	0.0354***	0.0213***	0.0163***	0.0181***	0.0131***	0.0075***	-0.0037	0.0068***	0.0067**
Stable firm (y/n)	-0.0331***	-0.0088***	-0.0113***	-0.0057**	0.0032*	-0.0045*	-0.0153***	-0.0084**	-0.0292***	-0.0187***
Exporting firm (y/n)	0.0088***	0.0295***	-0.0164***	0.0037	0.0046**	0.0004	0.0017	0.0090***	0.0216***	0.0241***
Part of foreign group (y/n)	-0.1328***	-0.1556***	-0.0765***	-0.1534***	-0.1171***	-0.1340***	-0.1218***	-0.1198***	-0.0739***	-0.1091***
Part of domestic group (y/n)	-0.0401***	-0.0507***	-0.0381***	-0.0470***	-0.0316***	-0.0439***	-0.0453***	-0.0485***	-0.0043*	-0.0170***
Manufacturing	0.0899***	0.1116***	0.0752***	0.1303***	0.0548***	0.0932***	0.0572***	0.0834***	0.0353***	0.0653***
Constant	0.6822***	0.4104***	0.7107***	0.5268***	0.6663***	0.5474***	0.7645***	0.6747***	0.6984***	0.5431***
Observations (weighted)	378,500	216,512	378,500	216,512	378,500	216,512	378,500	216,512	378,500	216,512
pseudo R2	0.094	0.156	0.061	0.109	0.056	0.083	0.045	0.083	0.054	0.070
ll	-245,111	-131,375	-248,458	-137,965	-236,535	-135,357	-227,187	-129,280	-220,948	-121,461
Country group 4										
R&D innovators	0.2438***	0.2856***	0.2834***	0.2200***	0.1148***	0.1435***	0.1401***	0.1324***	0.0934***	0.1342***
Non-technological innovators	0.1633***	0.2172***	0.1723***	0.1335***	0.1081***	0.0859***	0.1118***	0.0563***	0.0961***	0.1081***
Barrier-related non-innovators	0.4132***	0.4442***	0.2909***	0.3076***	0.2319***	0.2634***	0.2179***	0.2468***	0.2623***	0.2648***
Firm size	0.0006	-0.0157***	0.0000	-0.0190***	-0.0044*	-0.0130***	-0.0037*	-0.0131***	-0.0106***	-0.0131***
Fast growing firm (y/n)	-0.0049	-0.0315***	0.0466***	0.0081	0.0378***	0.0095	0.0198***	0.0087	0.0051	-0.0078
Stable firm (y/n)	-0.0164**	-0.0162***	0.0006	0.0524***	0.0133**	0.0183***	0.0018	0.0167***	0.0038	-0.0028
Exporting firm (y/n)	0.0355***	-0.0215***	-0.0028	0.0109**	0.0057	-0.0284***	0.0287***	-0.0127**	0.0252***	-0.0162***
Part of foreign group (y/n)	-0.1556***	-0.1300***	-0.0714***	-0.1014***	-0.0421***	-0.0931***	-0.0358***	-0.0652***	-0.0845***	-0.0598***
Part of domestic group (y/n)	-0.0606***	-0.0233**	0.0364***	0.0112	0.0055	-0.0367***	-0.0127	-0.0027	-0.0502***	0.0105
Manufacturing	0.0548***	0.0599***	0.0448***	0.0691***	0.0801***	0.0568***	0.0815***	0.0712***	0.0522***	0.0482***
Constant	0.2560***	1.2201***	-0.4510***	0.5861***	-0.5513***	0.6466***	-0.4751***	0.6303***	-0.1128*	0.7164***
Observations (weighted)	30,416	51,183	30,416	51,183	30,416	51,183	30,416	51,183	30,416	51,183
pseudo R2	0.127	0.156	0.070	0.080	0.051	0.063	0.050	0.056	0.057	0.059
ll	-18,875	-32,696	-19,295	-34,656	-17,015	-32,761	-16,761	-32,276	-18,063	-33,905

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.

4.2 Differences between country groups

In order to gain additional insight we estimate the baseline regressions for the country groups separately (table 5).⁷

In country group 1, all innovator types are most likely to experience skill barriers, while the other four barriers show similar levels of reporting. There is no difference in the relative importance by barrier across innovator types, suggesting no difference between hampering and deterring barriers. Barrier-related non-innovators are most likely to report barriers. As regards firm control variables, firm size and being part of foreign group function as they do in the pooled sample. The others differ in some instances, e.g. fast growing firms are more likely to experience skill barriers, while exporting firms face fewer skill barriers and more financial ones, yet both are more likely to report a lack of innovation partners.

In country group 2, all innovator types rank financial and skill barriers first, but R&D innovators and non-technological innovators experience skill barriers more often than barrier-related non-innovators, for which financial barriers are the biggest barrier – an occasion where hampering and deterring barriers are to some extent different. All the firm control variables mostly work as in the pooled sample with the exception of being part of a domestic group in CIS 4, but not in CIS 2006.

In country group 3, all innovator types are most likely to experience financial barriers, followed by skill barriers and the three knowledge barriers information on markets, technology and innovation partners. However, deterring barriers differ somehow from hampering barriers in that, for barrier-related non-innovators, the three knowledge barriers are also ranked high in country group 3. Hence, in country group 3 barrier-related non-innovators are highly likely to experience all of the barrier types investigated in our study. The other firm control variables work as in the pooled sample, with the exception of the lack of information on markets for large firms and skill barriers for exporting firms.

In country group 4, all innovator types rank financial barriers first, followed by skill barriers. In addition, as in country group 3, the three knowledge barriers are ranked highly among barrier-related non-innovators. The firm control variables of firm size, being part of a group and being a manufacturing firm act as they do in the pooled sample. Fast-growing firms, exporting and stable firms show some different patterns: fast-growing firms are less likely to experience financial barriers, while stable firms are more likely to experience barriers in some areas. In group 4, the fast-growing firms are probably successful firms, while firms which are stable in quickly growing markets – such as those in group 4 – are probably facing difficulties. The sign of barrier perception jumps around for exporting firms between CIS 4 and CIS 2006. This is most probably due to sampling. In all country groups, barrier-related non-innovators are most likely to experience barriers to innovation.

⁷ The results of the country group regressions are listed in appendix A and B.

Table 6: Differences of coefficients between country groups using country group regressions, CIS 4 and CIS 2006, innovator types

	CG1 vs CG2		CG1 vs CG3		CG1 vs CG4		CG2 vs CG3		CG2 vs CG4		CG3 vs CG4	
	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS4	CIS2006	CIS4	CIS2006	CIS4	CIS2006	CIS4	CIS2006
Lack of technical knowledge												
R&D innovators	0.024	-0.105	-0.013	-0.038	CG1>CG3	CG1>CG4	-0.037	0.068	-0.044	0.053	-0.007	-0.020
Non-technology innovators	-0.082	-0.032	-0.018	0.055	CG1>CG3	CG1>CG4	0.064	0.087	0.046	0.022	-0.018	-0.083
Barrier-related non-innovators	-0.043	0.014	0.056	0.174	CG1<CG3	CG1<CG4	0.099	0.160	0.040	0.072	-0.059	-0.172
					CG2<CG3	CG2<CG4						CG3>CG4
					CG2<CG3	CG2<CG4						CG3>CG4
Lack of market knowledge												
R&D innovators	0.022	-0.122	-0.079	-0.061	CG1>CG3	CG1>CG4	-0.101	0.062	-0.046	0.033	0.055	-0.048
Non-technology innovators	-0.047	-0.033	-0.052	0.034	CG1>CG3	CG1>CG4	-0.006	0.066	0.032	-0.007	0.038	-0.092
Barrier-related non-innovators	-0.054	0.020	-0.023	0.180	CG1<CG3	CG1<CG4	0.032	0.160	0.003	0.068	-0.029	-0.186
					CG2<CG3	CG2<CG4						CG3>CG4
Lack of innovation partners												
R&D innovators	-0.037	-0.096	-0.040	0.016	CG1>CG3	CG1>CG4	-0.003	0.111	-0.020	0.066	-0.017	-0.184
Non-technology innovators	-0.041	-0.042	-0.077	0.016	CG1>CG3	CG1>CG4	-0.036	0.058	0.033	0.078	0.069	-0.053
Barrier-related non-innovators	-0.024	0.010	0.018	0.085	CG1<CG3	CG1<CG4	0.043	0.075	0.034	0.055	-0.008	-0.069
					CG2<CG3	CG2<CG4						CG3>CG4
Financial barriers												
R&D innovators	0.055	-0.006	0.044	0.142	CG1<CG3	CG1<CG4	-0.011	0.148	0.016	0.116	0.027	-0.100
Non-technology innovators	0.045	0.055	0.054	0.119	CG1<CG3	CG1<CG4	0.009	0.064	0.027	0.093	0.018	-0.051
Barrier-related non-innovators	0.114	0.139	0.113	0.224	CG1<CG3	CG1<CG4	-0.001	0.085	0.038	0.061	0.039	-0.082
					CG2<CG3	CG2<CG4						CG3>CG4
Skill barriers												
R&D innovators	0.035	-0.065	-0.082	-0.147	CG1>CG3	CG1>CG4	-0.116	-0.082	0.010	-0.053	0.126	0.114
Non-technology innovators	-0.092	-0.038	-0.090	-0.052	CG1>CG3	CG1>CG4	0.002	-0.014	0.044	-0.053	0.042	-0.086
Barrier-related non-innovators	-0.098	-0.069	-0.075	0.019	CG1>CG3	CG1>CG4	0.024	0.087	0.006	0.001	-0.018	-0.111
					CG2<CG3	CG2<CG4						CG3>CG4

Source: CIS 4 and CIS 2006 data accessed at the safe centre. Coefficients and statistical significance reported. The sign of the coefficient indicates the country group which has the higher (more positive) coefficient, as it is the difference between the two coefficients. A negative relationship indicates that the first country, e.g. in the first column country group 1, has the higher coefficient. A positive coefficient indicates that the second country, e.g. in the first column country group 2, has the higher coefficient. Country_group_1: Belgium, Denmark, Germany, Finland, France, Iceland, Luxembourg, 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 7: Differences of coefficients between country groups using country group regressions, CIS 4&CIS 2006, firm control variables

	CG1 vs CG2		CG1 vs CG3		CG1 vs CG4		CG2 vs CG3		CG2 vs CG4		CG3 vs CG4	
	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006	CIS 4	CIS 2006
Lack of technical knowledge												
Gazelle (y/n)	0.046	0.003	0.019	0.013	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.020	-0.018
Stable (y/n)	-0.002	0.012	0.020	0.006	CG1<CG3	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.010	0.013
Exporting (y/n)	0.015	0.031	0.007	0.017	CG1<CG3	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.001	-0.040
Part of foreign group	-0.031	-0.071	-0.101	-0.147	CG1>CG3	CG1>CG3	CG1>CG4	CG1>CG4	CG1>CG4	CG1>CG4	0.075	-0.005
Part of domestic group	0.050	0.045	-0.023	0.004	CG1<CG2	CG1<CG2	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.037	-0.039
Lack of market knowledge												
Gazelle (y/n)	0.045	-0.002	0.006	0.010	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.012	0.011
Stable (y/n)	-0.024	0.030	-0.013	0.016	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.017	0.029
Exporting (y/n)	0.039	0.019	0.006	0.014	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.027	-0.026
Part of foreign group	-0.039	-0.069	-0.096	-0.128	CG1>CG2	CG1>CG3	CG1>CG4	CG1>CG4	CG1>CG4	CG1>CG4	0.086	0.032
Part of domestic group	0.018	0.030	-0.044	-0.002	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.033	0.013
Lack of innovation partners												
Gazelle (y/n)	0.014	-0.013	-0.001	-0.006	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	-0.002	-0.009
Stable (y/n)	-0.038	0.036	-0.036	0.009	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.033	0.014
Exporting (y/n)	0.025	0.003	0.015	0.009	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.004	-0.052
Part of foreign group	-0.034	-0.037	-0.033	-0.082	CG1>CG2	CG1>CG3	CG1>CG4	CG1>CG4	CG1>CG4	CG1>CG4	-0.011	0.038
Part of domestic group	0.018	0.000	0.005	0.020	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	-0.046	0.004
Financial barriers												
Gazelle (y/n)	0.008	0.031	0.010	0.073	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	-0.017	-0.094
Stable (y/n)	-0.020	0.063	-0.019	0.039	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.017	-0.027
Exporting (y/n)	0.026	0.026	-0.001	0.018	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.027	-0.052
Part of foreign group	-0.118	-0.122	-0.124	-0.133	CG1>CG2	CG1>CG3	CG1>CG4	CG1>CG4	CG1>CG4	CG1>CG4	-0.023	-0.015
Part of domestic group	-0.011	-0.019	-0.069	-0.033	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	-0.021	0.018
Skill barriers												
Gazelle (y/n)	0.002	-0.016	-0.005	-0.004	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.025	-0.026
Stable (y/n)	-0.007	0.026	0.007	0.034	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.012	0.049
Exporting (y/n)	0.048	0.053	0.020	0.036	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.014	0.009
Part of foreign group	0.001	-0.089	-0.017	-0.159	CG1>CG2	CG1>CG3	CG1>CG4	CG1>CG4	CG1>CG4	CG1>CG4	0.005	0.024
Part of domestic group	0.039	0.059	-0.022	0.032	CG1<CG2	CG1<CG3	CG1<CG4	CG1<CG4	CG1<CG4	CG1<CG4	0.075	0.035

Source: CIS 4 and CIS 2006 data accessed at the safe centre. Coefficients and statistical significance reported. The sign of the coefficient indicates the country group which has the higher (more positive) coefficient, as it is the difference between the two coefficients. A negative relationship indicates that the first country, e.g. in the first column country group 1, has the higher coefficient. A positive coefficient indicates that the second country, e.g. in the first column country group 2, has the higher coefficient. Country group 1: Belgium, Denmark, Germany, Finland, France, Iceland, Luxembourg, 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.

From the separate country group regressions, it is impossible to extrapolate the statistical significance of the differences in the perception of barriers by innovator types in different country groups. This means that we cannot, for example, show if there are significant differences in deterring barriers – that is, in the perception of barriers by barrier-related non-innovators – between the country groups. Hence, we explicitly test for these differences, i.e. for the equality of coefficients of the explanatory variables, in order to present results that allow us to differentiate the perception of barriers between country groups for similar firm types. We proceed as follows: we run an LPE regression using a sample of two country groups. The coefficients are interacted with a dummy variable indicating from which country group the observation comes. The regression yields LPE coefficients for one country group (the country group with the lower number) while the interaction term shows the difference of coefficient between the two country groups in the sample. Table 6 (innovator types) and Table 7 (firm control variables) present the differences of coefficients between country groups. A positive expression indicates the coefficient for the second country group is higher, while a negative expression indicates that the coefficient for the first country group is higher. The regressions run were the same as the baseline regressions except for the inclusion of country group dummies. In the column next to the difference between the coefficients, we report which group has the higher coefficient only if the coefficient in CIS 4 and shares the same sign and if at least one is significant at the 5%-level.

The results in tables 6 and 7 provide some interesting insights with respect to the different factors affecting the perception of innovation barriers across country groups and firm types:

- **Firm types:** With respect to innovative behaviour, we are able to report interesting differences between the country groups. Across innovator types, skill barriers matter most in the group of technologically advanced countries (group 1), while financial barriers matter most in the technologically less intensive country groups 3 and 4.
- **Deterring barriers:** Barrier-related non-innovators are most likely to perceive barriers in country group 3, followed by country group 4; barrier-related non-innovators in group 1 are mostly affected by skill barriers, while those in group 2 are affected by financial barriers.
- **Hampering barriers:** Non-technological innovators and R&D innovators of country group 1 are overall most affected by barriers, with the exception of financial barriers, followed by group 3 and 4. R&D innovators in groups 2 and 4 are most affected by skill barriers.
- **Other firm control variables:** High-growth firms in country group 1 do generally report that they were affected less by innovation barriers than high growth firms in the other country groups, in particular as regards information on technology and financial barriers. Among stable firms, firms from country group 1 generally experience fewer barriers, while firms from group 4 experience more. This should not be surprising, as stable firms in country group 1 will be a more “normal” group of firms when compared with market growth, whereas in the quickly growing markets of group 4 stable firms are potentially problem-struck.

- **Export-active firms:** Exporting firms in country group 1 do generally report that they are affected less by innovation barriers than export-active firms in other country groups, while firms from the group of technologically advanced catching-up countries report more barriers. For these firms it seems to be particularly difficult to combine exporting with innovation, confirming Gorodnichenko and Schnitzer (2010). In group 1 it is likely that more advanced support frameworks are in place – for both exporting and innovating, and that the financial system is more developed, allowing for export and innovation financing.
- **Firms in a foreign group:** The coefficient for firms that are part of a foreign group is higher in country group 1 than for the other country groups, probably because firms in group 1 are more likely to be part of the innovation-producing network of foreign groups, whereas in other country groups the activity of firms which are part of a foreign group is possibly more production-oriented.

These results show how institutional and economic differences may shape innovation activities.

4.3 Robustness

Table 8 presents robustness results that can be compared to the baseline results in table 4 in order to assess the robustness of the results with regard to changes in the definition of barrier-related non-innovators. We report the results for three changes in definition:

1. We exclude all barrier-related non-innovators that ranked all obstacles at the maximum (high). This allows us to check whether the results are driven by firms which indiscriminately assess all barriers as high. It is possible that such behaviour does not provide actual information on the importance of the specific barriers.
2. We distinguish in a different way between barrier-related and non-barrier-related non-innovators by considering the average value for R&D innovators instead of the average for all firms. The rationale behind this is to check whether the results are robust to a slight change in the definition of barrier-related and non-barrier-related innovators.
3. We distinguish between barrier-related and non-barrier-related non-innovators by considering the average value for R&D innovators instead of the average for all firms and do not consider the answers to the “No need for innovation” questions.

A comparison of the results in tables 8 and 4 for CIS 4 clearly shows that the first two modifications did not change the qualitative nature of the results. In contrast, by using definition 3 the magnitude of the coefficients for R&D innovators, non-technological innovators and barrier-related non-innovators changes considerably, as do the coefficients for many other variables. Nevertheless, the signs of the coefficients remain the same.

Table 8: Robustness analysis: Regression results using modifications of the definition of barrier-related non-innovators, CIS 4

	Exclusion of all firms that rank all obstacles at maximum in the group of barrier-related non-innovators				Change in definition of barrier-related non-innovators				Reference for calculating the boundary at not all firms but only R&D innovators and questions regarding prior innovation were not considered				
	Financial barriers	Skill barriers	Lack of information on markets	Lack of information on technology	Financial barriers	Skill barriers	Lack of information on technology	Lack of information on markets	Financial barriers	Skill barriers	Lack of information on technology	Lack of information on markets	Lack of innovation partners
R&D innovators	0.2024***	0.1984***	0.1317***	0.1284***	0.1986***	0.1933***	0.1294***	0.1264***	0.3284***	0.3300***	0.2498***	0.2479***	0.2454***
Non-technological innovators	0.1304***	0.1565***	0.1247***	0.0914***	0.1270***	0.1518***	0.1226***	0.0897***	0.2614***	0.2933***	0.2472***	0.2154***	0.1742***
Barrier-related non-innovators	0.3388***	0.3239***	0.2549***	0.2438***	0.3684***	0.3437***	0.2802***	0.2695***	0.5141***	0.5215***	0.4493***	0.4474***	0.4463***
Firm size	-0.0152***	-0.0096***	-0.0090***	-0.0061***	-0.0150***	-0.0095***	-0.0088***	-0.0060***	-0.0115***	-0.0057***	-0.0064***	-0.0025***	-0.0037***
Fast growing firm (y/n)	0.0098***	0.0255***	0.0162***	0.0085***	0.0107***	0.0265***	0.0169***	0.0091***	0.0084***	0.0238***	0.0145***	0.0066***	0.0064***
Stable firm (y/n)	-0.0287***	-0.0150***	-0.0076***	-0.0144***	-0.0280***	-0.0144***	-0.0071***	-0.0139***	-0.0226***	-0.0087***	-0.0020*	-0.0088***	-0.0111***
Exporting firm (y/n)	0.0127***	-0.0154***	0.0047***	0.0046***	0.0134***	-0.0147***	0.0051***	0.0051***	0.0097***	-0.0185***	0.0019*	0.0018	0.0157***
Part of foreign group (y/n)	-0.0067***	-0.0658***	-0.0517***	-0.0593***	-0.0731***	-0.0664***	-0.0519***	-0.0594***	-0.0560***	-0.0480***	-0.0355***	-0.0428***	-0.0377***
Part of domestic group (y/n)	0.0732***	-0.0233***	-0.0233***	-0.0196***	-0.0073***	-0.0239***	-0.0188***	-0.0200***	-0.0043***	-0.0207***	-0.0159***	-0.0170***	-0.0064***
Manufacturing	-0.0431***	0.0607***	0.0529***	0.0585***	0.0764***	0.0639***	0.0652***	0.0607***	0.0672***	0.0539***	0.0463***	0.0516***	0.0277***
Medium-low innovation	-0.0214***	0.0089***	-0.0381***	-0.0122***	-0.0246***	0.0058**	-0.0404***	-0.0144***	-0.0248***	0.0062**	-0.0398***	-0.0136***	-0.0043*
Medium-high innovation	0.0169***	0.0028	-0.0483***	-0.0065*	-0.0292***	0.0185***	-0.0397***	-0.0118***	-0.0337***	0.0142***	-0.0433***	-0.0154***	0.0075**
High innovation	-0.1664***	-0.0665***	-0.0754***	-0.0581***	-0.0949***	-0.0653***	-0.0746***	-0.0573***	-0.0924***	-0.0650***	-0.0422***	-0.0324***	-0.0851***
Country group 1	-0.0961***	0.0096***	0.0481***	0.0227***	0.0006	0.0102***	0.0486***	0.0232***	-0.0138**	-0.0043**	0.0361***	0.0107***	-0.0343***
Country group 2	0.6382***	0.6193***	0.5020***	0.4742***	0.6274***	0.6109***	0.4932***	0.4653***	0.4516***	0.4253***	0.3297***	0.3004***	0.4212***
Constant	707.373	707.434	707.397	707.392	707.373	707.434	707.397	707.392	707.373	707.434	707.397	707.392	707.400
Observations (weighted)	0.118	0.074	0.066	0.055	0.122	0.074	0.069	0.059	0.261	0.220	0.199	0.196	0.199
pseudo R2	-415.681	-451.300	-400.980	-391.220	-414.132	-451.025	-399.742	-389.888	-460.098	-478.310	-424.998	-411.331	-404.431
II													

Source: CIS 4 data accessed at the safe centre. t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Country group 1: Belgium, Denmark, Germany, Finland, France, Iceland, Luxembourg, 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.

5. Discussion and Conclusions

In this research we studied the propensity to rank innovation barriers as relevant to inhibiting innovation activities across firm types and across a large number of EU member States. The findings confirm the relevance of the distinction between hampering and deterring barriers to innovation emphasized by D'Este et al. (2012). In our view, this furthers the possibilities of the barrier approach to innovation in providing valuable policy insights. Appropriately distinguishing between firms interested or not interested in innovation presents a challenge for empirical researchers. It is, however, necessary in order to inform policies that aim to increase the share of enterprises engaged in innovation activities.

The results in this paper clearly suggest that non-innovative firms interested in taking up innovation activities constitute the group of firms most affected by innovation barriers. This provides an important qualification of the result of previous studies of innovation barriers, which found that innovative firms are more likely to perceive barriers to innovation.

Our findings indicate that there are important differences across countries. Firms in country group 3 (Southern European countries with low technological intensity and a higher per capita GDP) report the highest barriers to innovation, together with firms in the group of countries with low overall technological intensity (group 4 – catching-up countries). On average, firms in country group 1 (advanced countries) report the lowest incidence of innovation barriers.

However, we also see important differences across the different barriers.

Our research largely confirms previous results but provides more insight into the question of which barriers matter for which country and innovator type. R&D and non-technological innovators are most hampered by financial barriers in country groups 3 and 4, while they especially suffer from knowledge barriers (lack of information on technology, markets and potential innovation partners) and skill barriers in group 1. This mirrors innovative activity in countries close to the frontier, often relying on highly specialised skills and collaboration with other firms to be able to master advancing technological complexity.

From an innovation policy perspective, it is important to know whether hampering and deterring barriers are different, as different sets of policies would be needed to target a rise in innovation intensity and/or a rise in the propensity to engage in innovative activity. We find that hampering barriers in group 3 are predominantly financial, while deterring barriers are related to all of the barriers investigated in this paper, namely financial, skill and knowledge barriers. Hampering barriers in groups 2 and 4 are mostly skill barriers for R&D innovators, while deterring barriers are mostly financial. In group 1, there is little difference.

Overall, our results suggest that – across the board – innovation barriers are less likely to be perceived in countries closer to the technological frontier than in countries further away from the frontier. Although we have not taken into account the impact of barriers on innovative activity, this implicitly suggests that barriers to innovation impede economic development. If reporting barriers to innovation were merely a sign of successful firms having overcome them, the firms in countries close to the technological frontier should, on average, report higher barriers than firms in countries far from the frontier. However, our results do not offer an answer to the question of whether the interaction of the perception of innovation barriers with the distance to the frontier is (i) a result of advanced firms being more capable of carrying out innovative activities, (ii) a result of different institutional environments, such as

the different stages of development of the financial system, or (iii) the result of more extensive innovation policy support in countries close to the frontier. This is clearly a task for further research.

With regard to specific barriers to innovation, the finding that financing constraints to innovative activity are assessed as more important in countries far from the frontier, while skill constraints are perceived as more relevant in frontier countries, suggests that financial development relaxes financing constraints to innovation, but does not help in closing the skill constraints. Thus, we think that our results suggest that an excessively narrow focus on business R&D and innovation promotion, e.g. by way of R&D tax credits or direct innovation subsidy schemes, is likely to be misguided in countries close to the frontier. This interpretation mirrors the results of Leiponen (2005) for Finland, who warns that subsidies for innovation projects or the promotion of innovation consortia may lead to disappointing results if the targeted firms do not possess the requisite complementary skill base.

Our results indicate that combinations of different firm characteristics are associated with the perception of higher barriers to innovation. Small, independent and growing firms seem to merit more attention from policy makers than the average firms in all country groups. However, a conclusive analysis of this issue must explicitly investigate these firm characteristics for the different innovator types, e.g., whether large, non-innovative firms do not innovate by choice. Thus, we are convinced that further and more detailed comparative research on the importance of innovation barriers across countries using firm-level data is likely to offer new insights, especially if deterring and hampering barriers are studied separately. We believe that innovation barriers should get more attention from innovation researchers. This would increase the ability of the innovation barrier approach to provide useful, validated results for priority-setting in innovation policy.

References

- Acemoglu, D., Aghion P., Zilibotti F. 2006. Distance to frontier, selection, and economic growth. *Journal of the European Economic Association* 4, 37-74.
- Aghion, P., Howitt, P., 2006. Joseph Schumpeter Lecture Appropriate Growth Policy: A Unifying Framework. *Journal of the European Economic Association* 4, 269–314.
- Angrist, J.D., Pischke, J. S., 2008. *Mostly harmless econometrics: an empiricist's companion*. Princeton University Press.
- Arundel, A., 1997. Enterprise strategies and barriers to innovation, in: Arundel, A., Garrelfs, R. (Eds), *Innovation Measurement and Policies*, EIMS Publication Vol. 50, European Commission, pp. 101-108.
- Assink, M., 2006. Inhibitors of disruptive innovation capability: a conceptual model. *European Journal of Innovation Management* 9, 215–233.
- Baldwin, J., Lin, Z., 2002. Impediments to advanced technology adoption for Canadian manufacturers. *Research Policy* 31, 1–18.
- Baumol, W.J., 2008. Small enterprises, large firms, productivity growth and wages. *Journal of Policy Modeling* 30, 575–589.
- Canepa, A., Stoneman, P., 2008. Financial constraints to innovation in the UK: evidence from CIS2 and CIS3. *Oxford Economic Papers* 60, 711–730.
- Cassiman, B., Veugelers, R., 2002. R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium. *The American Economic Review* 92, 1169–1184.
- Coad, A., Hölzl, W., 2012. Firm Growth: Empirical Analysis, in: Dietrich, M., Krafft, J. (Eds), *Handbook on the Economics and Theory of the Firm*. Edward Elgar Publishing, Cheltenham (UK) – Northampton (MA, USA).
- Coad, A., Rao, R., 2008. Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research Policy* 37, 633–648.

- Cohen, W.M., Klepper, S., 1996. Firm size and the nature of innovation within industries: the case of process and product R&D. *The review of Economics and Statistics* 78, 232–243.
- Criscuolo, C., Squicciarini, M., Lehtoranta, O., 2010. R&D, Innovation and Productivity, and the CIS: Sampling, Specification and Comparability Issues. Contributed paper for the 2nd Conference on corporate R&D (CONCORD).
- D’Este, P., Iammarino, S., Savona, M., Von Tunzelmann, N., 2008. What hampers innovation? Evidence from the UK CIS 4. SPRU Electronic Working Paper Series 168.
- D’Este, P., Iammarino, S., Savona, M., von Tunzelmann, N., 2012. What hampers innovation? Revealed barriers versus deterring barriers. *Research Policy* 41, 482–488.
- Eurostat-OECD (2008), Eurostat-OECD Manual on Business Demography Statistics, European Communities, Luxembourg.
- Fitjar, R.D., Rodríguez-Pose, A., 2011. Firm collaboration and modes of innovation in Norway. CEPR Discussion Paper No. DP8484.
- Galia, F., Legros, D., 2004. Complementarities between obstacles to innovation: evidence from France. *Research Policy* 33, 1185–1199.
- Gorodnichenko, Y., Schnitzer, M., 2010. Financial constraints and innovation: Why poor countries don’t catch up. National Bureau of Economic Research Working Paper Series No. 15792.
- Hadjimanolis, A., 2003. The barriers approach to innovation, in: Shavinina, L.V. (Ed), *The International Handbook on Innovation*. Pergamon Press, Amsterdam, pp. 559–573.
- Henrekson, M., Johansson, D., 2009. Gazelles as job creators: a survey and interpretation of the evidence. *Small Business Economics* 35, 227–244.
- Hölzl, W., 2009. Is the R&D behaviour of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Business Economics* 33, 59–75.
- Hölzl, W., Friesenbichler, K., 2010. High-growth firms, innovation and the distance to the frontier. *Economics Bulletin* 30(2), 1016-1024.
- Hölzl, W., Reinstaller, A., 2009. Market Structure: Sector Indicators, in Peneder, M. (ed.), *Sectoral Growth Drivers and Competitiveness in the European Union*, European Communities, Luxembourg, pp. 393-459.
- Iammarino, S., Sanna-Randaccio, F., Savona, M., 2009. The perception of obstacles to innovation. Foreign multinationals and domestic firms in Italy. *Revue d’économie industrielle* 1(125), 75–104.
- Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B. Å, 2007. Forms of knowledge and modes of innovation. *Research Policy* 36, 680–693.
- Leiponen, A., 2005. Skills and innovation. *International Journal of Industrial Organization* 23, 303–323.
- Mairesse, J., Mohnen, P., 2005. The Importance of R&D for Innovation: A Reassessment Using French Survey Data, in: *Essays in Honor of Edwin Mansfield*, pp. 129–143.
- Mirow, C., Hölzle, K., Gemünden, H.G., 2007. Systematisierung, Erklärungsbeiträge und Effekte von Innovationsbarrieren. *Journal für Betriebswirtschaft* 57, 101–134.
- Mohnen, P., Palm, F., van der Loeff, S., Tiwari, A., 2008. Financial Constraints and Other Obstacles: are they a Threat to Innovation Activity? *De Economist* 156, 201–214.
- Mohnen, P., Rosa, J., 2002. Barriers to innovation in service industries in Canada, in: Feldman, M., *Institutions and Systems in the Geography of Innovation - Economics of Science, Technology and Innovation*, Volume 25, Part II, pp. 231-250.
- Mohnen, P., Röller, L.-H., 2005. Complementarities in innovation policy. *European Economic Review* 49, 1431–1450.
- Peneder, M., 2010. Technological regimes and the variety of innovation behaviour: Creating integrated taxonomies of firms and sectors. *Research Policy* 39, 323–334.
- Reinstaller, A., Unterlass, F., 2011. Sectoral Innovation Modes and Level of Economic Development: Implications for Innovation Policy in the New Member States, in: Radosevic, S., Kaderabkova, A. (Eds), *Challenges For European Innovation Policy. Cohesion and Excellence from a Schumpeterian Perspective*. Edward Elgar Publishing, Cheltenham (UK) – Northampton (MA, USA).
- Savignac, F., 2008. The impact of financial constraints on innovation: what can be learned from a direct measure? *Economics of Innovation and New Technology* 17, 553–569.
- Tang, H.K., Yeo, K.T., 2003. Innovation under constraints: The case of Singapore, in: Shavinina, L.V. (Ed), *The International Handbook on Innovation*. Elsevier, Amsterdam, pp. 873–881.

Appendix A: Country group regressions – CIS 4

VARIABLES	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	
Log firms size	-0.0164** (-1.7407)	-0.0140** (-1.342)	-0.0119** (-1.2951)	-0.0173** (-1.8930)	-0.0156** (-1.4362)	-0.0166** (-1.7140)	-0.0070** (-0.6499)	-0.0021** (-0.1740)	-0.0157** (-1.6677)	-0.0033** (-0.3272)	-0.0023** (-0.231)	0.0027** (0.3053)	-0.0042** (-0.3780)	-0.0033** (-0.3272)	-0.0037** (-0.349)	-0.0037** (-0.349)	-0.0037** (-0.349)	-0.0037** (-0.349)	0.0006 (0.248)	-0.0049 (-0.404)	0.0000 (0.011)
Gazette (y/n)	-0.0005 (-0.140)	0.0003 (0.370)	0.007** (2.189)	0.0366** (0.808)	0.0027 (0.708)	0.0046** (1.133)	0.0061** (1.55)	0.0217** (5.73)	0.0104 (2.81)	0.0048** (1.133)	0.0181** (4.81)	0.0075** (2.08)	0.0068** (1.85)	0.025** (7.22)	0.0198** (5.498)	0.0088** (2.42)	0.0088** (2.42)	0.0088** (2.42)	-0.0049 (-0.404)	0.0006 (0.248)	0.0000 (0.011)
Stable (y/n)	-0.0164** (-1.7407)	-0.0026 (-0.646)	0.0068** (1.739)	-0.0138** (-3.580)	-0.0182** (-4.81)	-0.0268** (-6.863)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0319** (-8.13)	-0.0164** (-1.7407)	-0.0026 (-0.646)	0.0068** (1.739)
Exporting (y/n)	-0.0027 (-0.6796)	-0.0045** (-1.392)	0.0067** (1.739)	0.0097** (2.580)	-0.0366** (-8.481)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	0.0349** (8.13)	-0.0027 (-0.6796)	-0.0045** (-1.392)	0.0067** (1.739)
Part of foreign group	-0.0161** (-4.327)	-0.0260** (-6.298)	-0.0410** (-10.936)	-0.0088** (-2.16)	-0.0597** (-15.17)	-0.0648** (-17.36)	-0.0745** (-20.364)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.1268** (-32.64)	-0.0161** (-4.327)	-0.0260** (-6.298)	-0.0410** (-10.936)
Part of domestic group	-0.0082** (-2.157)	-0.0010 (-0.26)	-0.0091** (-2.32)	0.0288** (7.481)	-0.0157** (-4.41)	0.0169** (4.81)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	0.0084 (2.32)	-0.0082** (-2.157)	-0.0010 (-0.26)	-0.0091** (-2.32)
Manufacturing	0.0393** (10.446)	0.0446** (11.17)	0.0267** (8.628)	0.0387** (10.446)	0.0329** (9.033)	0.0563** (14.49)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0339** (8.66)	0.0393** (10.446)	0.0446** (11.17)	0.0267** (8.628)
Medium-low innovation	-0.0735** (-1.958)	-0.0522** (-1.417)	-0.0426** (-1.179)	-0.0451** (-1.295)	0.0206** (0.633)	-0.0475** (-1.345)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0667** (-1.670)	-0.0735** (-1.958)	-0.0522** (-1.417)	-0.0426** (-1.179)
Medium innovation	-0.0281** (-6.687)	-0.0062 (-1.489)	-0.0275** (-6.692)	0.0038 (0.924)	0.0621** (12.872)	-0.0137 (-3.808)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0207** (-5.706)	-0.0281** (-6.687)	-0.0062 (-1.489)	-0.0275** (-6.692)
Medium-high innovation	-0.0143* (-3.953)	0.0173** (4.172)	-0.0091 (-2.26)	0.0316** (7.481)	0.1278** (14.374)	-0.0211* (-5.653)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0253** (-6.872)	-0.0143* (-3.953)	0.0173** (4.172)	-0.0091 (-2.26)
High innovation	-0.0169** (-2.169)	0.0194** (4.92)	-0.0056 (-1.492)	0.0359** (9.055)	0.1379** (16.194)	0.0103 (2.626)	0.0042 (1.106)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0139 (-3.406)	-0.0169** (-2.169)	0.0194** (4.92)	-0.0056 (-1.492)
Business	0.0578** (2.101)	-0.0190 (-4.691)	0.2867** (9.528)	-0.0766** (-2.844)	-0.4201** (-12.266)	0.0046 (1.000)	0.0088 (2.332)	0.2531** (7.332)	-0.0008 (-0.15)	-0.1871** (-5.386)	-0.0164 (-4.27)	0.0214 (5.34)	0.0191 (4.94)	0.1651** (4.313)	-0.0029** (-0.2583)	-0.0029** (-0.2583)	-0.0029** (-0.2583)	-0.0029** (-0.2583)	0.0578** (2.101)	-0.0190 (-4.691)	0.2867** (9.528)
Cumulativeness	-0.0750** (-6.476)	0.0072 (0.624)	-0.1006** (-3.803)	-0.0431** (-9.567)	-0.1274** (-33.803)	-0.1955** (-5.491)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.2394** (-6.872)	-0.0750** (-6.476)	0.0072 (0.624)	-0.1006** (-3.803)
R&D innovators	0.1347** (4.9713)	0.1640** (6.0513)	0.1498** (5.6481)	0.1724** (6.508)	0.2391** (7.6706)	0.1863** (5.417)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1129** (2.938)	0.1347** (4.9713)	0.1640** (6.0513)	0.1498** (5.6481)
Non-technology innovators	0.1411** (3.5433)	0.1267** (3.170)	0.1041** (2.785)	0.0912** (2.266)	0.2207** (7.785)	0.0619** (1.609)	0.0799** (2.083)	0.0632** (1.630)	0.1561** (4.059)	0.1285** (3.258)	0.1260** (3.191)	0.0713** (1.858)	0.0275** (0.700)	0.1454** (3.439)	0.1304** (3.258)	0.1304** (3.258)	0.1304** (3.258)	0.1304** (3.258)	0.1411** (3.5433)	0.1267** (3.170)	0.1041** (2.785)
Barrier-related non-innovators	0.2350** (93.743)	0.2095** (107.522)	0.2523** (102.830)	0.2614** (106.602)	0.3384** (132.986)	0.1922** (46.374)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2381** (50.789)	0.2350** (93.743)	0.2095** (107.522)	0.2523** (102.830)
Constant	0.3556** (13.631)	0.1513** (3.800)	0.3411** (13.362)	0.2763** (10.829)	0.6494** (21.648)	0.5780** (11.939)	0.6759** (8.797)	0.6759** (8.797)	0.7891** (14.643)	0.5206** (9.467)	0.6663** (26.858)	0.7645** (31.590)	0.6984** (29.337)	-0.5513** (-8.365)	-0.4751** (-12.268)	-0.4751** (-12.268)	-0.4751** (-12.268)	-0.4751** (-12.268)	0.3556** (13.631)	0.1513** (3.800)	0.3411** (13.362)
Observations (weighted)	221,374	221,364	221,361	221,350	221,384	65,508	65,524	65,524	65,508	65,535	378,500	378,500	378,500	378,500	378,500	378,500	378,500	378,500	221,374	221,364	221,361
pseudo R2	0.053	0.066	0.062	0.068	0.101	0.052	0.064	0.067	0.121	0.086	0.056	0.045	0.054	0.094	0.061	0.051	0.050	0.057	0.053	0.066	0.062
II	-104525	-104490	-99759	-99601	-135513	-29197	-30600	-31369	-36225	-37582	-236535	-227187	-220948	-245111	-248458	-17015	-16761	-18063	-104525	-104490	-99759

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

Appendix B: Country group regressions – CIS 2006

VARIABLES	Country group 1				Country group 2				Country group 3				Country group 4			
	Lack of technical knowledge	Lack of innovation partners	Financial barriers	Skill barriers	Lack of technical knowledge	Lack of innovation partners	Financial barriers	Skill barriers	Lack of technical knowledge	Lack of innovation partners	Financial barriers	Skill barriers	Lack of technical knowledge	Lack of innovation partners	Financial barriers	Skill barriers
Log firms size	-0.0096** (-3.849)	-0.0135*** (-5.447)	-0.0173*** (-7.029)	0.0184*** (6.296)	0.0065*** (4.166)	0.0022 (1.303)	-0.0064*** (-3.557)	-0.0027 (-1.463)	-0.0088*** (-8.094)	-0.0100*** (-9.462)	-0.0020* (-1.933)	-0.0097*** (-9.070)	-0.0052*** (-4.690)	-0.0131*** (-7.120)	-0.0157*** (-8.464)	-0.0190*** (-9.877)
Gazette (y/n)	0.0004 (0.040)	-0.0139 (-1.344)	-0.0379*** (-3.712)	0.0200* (1.239)	0.0036 (0.683)	-0.0003 (-0.076)	-0.0003 (-0.048)	0.0037 (0.599)	0.0036 (3.799)	0.0131*** (-1.109)	0.0067** (2.086)	0.0354*** (10.478)	0.0163*** (4.682)	-0.0078 (1.504)	-0.0335*** (-3.382)	0.0081 (0.388)
Stable (y/n)	-0.0101* (-1.776)	-0.0240*** (-4.181)	-0.0481*** (-6.486)	-0.0400*** (-5.978)	0.0014 (0.367)	0.0056 (2.231)	0.0151*** (3.363)	-0.0137*** (-2.961)	-0.0045** (-1.973)	-0.0084*** (-3.754)	-0.0187*** (-8.708)	-0.0088*** (-3.912)	-0.0057*** (-2.466)	0.0167*** (3.258)	-0.0162*** (-4.495)	0.0524*** (8.975)
Exporting (y/n)	-0.0162*** (-2.973)	-0.0048 (0.152)	0.0152*** (2.797)	-0.0321*** (-3.025)	0.0146*** (3.883)	0.0178*** (4.505)	0.0375*** (7.160)	0.0210*** (4.723)	0.0004 (0.158)	0.0090*** (3.708)	0.0241*** (10.226)	0.0295*** (11.962)	0.0037 (1.468)	-0.0127*** (-2.634)	-0.0215*** (-3.249)	0.0109** (2.161)
Part of foreign group	0.0135** (2.450)	-0.0267*** (-4.881)	-0.0226*** (-4.120)	0.0055 (0.851)	-0.0580*** (-10.277)	-0.0638*** (-10.785)	-0.1451*** (-22.533)	-0.0835*** (-12.556)	-0.1340*** (-23.963)	-0.1198*** (-22.036)	-0.1091*** (-20.803)	-0.1556*** (-28.341)	-0.1534*** (-27.105)	-0.0652*** (-6.429)	-0.1300*** (-5.713)	-0.1044*** (-9.546)
Part of domestic group	-0.0477*** (-4.575)	-0.0463*** (-4.420)	-0.0368*** (-3.554)	-0.0180* (-1.741)	-0.0025 (-0.406)	-0.0167*** (-2.683)	-0.0371*** (-5.279)	-0.0200** (-2.735)	-0.0439*** (-12.642)	-0.0485*** (-14.355)	-0.0170*** (-5.231)	-0.0507*** (-14.871)	-0.0470*** (-13.367)	-0.0027 (-0.324)	-0.0233** (-1.968)	0.0112 (1.129)
Manufacturing	0.0669*** (8.688)	0.0215*** (2.799)	0.0334*** (4.393)	0.0055 (0.730)	0.0327*** (6.243)	0.0405*** (7.666)	0.0294*** (5.356)	0.0500*** (8.114)	0.0921*** (27.158)	0.0834*** (24.993)	0.0653*** (20.272)	0.1116*** (33.099)	0.1303*** (37.511)	0.0482*** (12.450)	0.0599*** (8.153)	0.0691*** (11.536)
Medium-low innovation	-0.0080 (-0.369)	-0.0082 (-0.386)	0.0285** (2.125)	0.0129 (1.816)	-0.0235*** (-2.747)	-0.0344*** (-3.983)	-0.0323*** (-3.606)	-0.0631*** (-6.268)	-0.0472** (-8.472)	-0.0576*** (-10.651)	-0.0133** (-2.542)	-0.0170*** (-3.104)	-0.0216*** (-3.834)	0.0111 (1.228)	0.0168* (1.662)	0.0144 (1.406)
Medium innovation	0.0134 (1.264)	0.0291*** (2.734)	0.0461*** (4.384)	0.0356*** (2.867)	0.0091 (1.264)	-0.0030 (-0.416)	-0.0002 (-0.032)	0.0158 (1.859)	-0.0309*** (-7.249)	-0.0235*** (-5.681)	0.0018 (0.459)	-0.0032*** (-7.942)	-0.0228*** (-5.296)	0.0466*** (5.482)	0.0124 (1.458)	0.0490*** (5.554)
Medium-high innovation	0.0650*** (3.630)	0.0489*** (2.723)	0.0574*** (3.231)	0.0898*** (4.285)	0.0158 (1.374)	-0.0064 (-0.547)	0.0033 (0.269)	-0.0020 (-0.147)	-0.0439*** (-10.328)	-0.0376*** (-6.054)	0.0203*** (3.393)	-0.0232*** (-3.094)	-0.0222*** (-3.435)	0.0150 (1.159)	-0.0003 (-0.022)	-0.0308** (-2.294)
High innovation	0.0276* (1.702)	0.0783*** (4.817)	0.0938*** (5.846)	0.1223*** (6.453)	-0.0085 (-0.793)	-0.0208* (-1.914)	-0.0009 (-0.079)	0.0281** (2.211)	-0.0379*** (-5.737)	-0.0181*** (-2.811)	0.0235*** (3.791)	0.0026 (0.403)	0.0146** (2.181)	-0.0261* (-1.903)	0.0235** (1.702)	-0.0038 (-0.268)
Businessness	-0.1892** (-2.403)	-0.0246 (-0.312)	0.0482 (1.925)	-0.1502* (-1.509)	0.0203*** (4.150)	0.3233*** (6.569)	0.3492*** (6.829)	0.2539*** (4.416)	-0.0469* (-1.653)	-0.1499*** (-4.62)	0.0364 (1.365)	0.1538*** (5.516)	-0.1062*** (-3.694)	0.0733 (1.167)	-0.2058*** (-3.171)	-0.0776 (-1.779)
Cumulative-ness	-0.2524*** (-6.322)	-0.2237*** (-5.581)	-0.3562*** (-9.001)	0.0173 (0.371)	-0.2565*** (-9.007)	-0.4255*** (-8.436)	-0.7811*** (-9.308)	-0.2692*** (-8.018)	-0.1161*** (-8.363)	-0.1943*** (-14.396)	-0.1583*** (-12.161)	-0.0827*** (-6.073)	-0.1024*** (-7.291)	-0.1808*** (-4.064)	-0.3930*** (-10.103)	-0.0951** (-2.303)
R&D innovators	0.1955*** (29.878)	0.2211*** (33.655)	0.1638*** (25.236)	0.3376*** (44.076)	0.0903*** (16.477)	0.0900*** (17.894)	0.0683*** (11.879)	0.1693*** (42.248)	0.1579*** (37.118)	0.1605*** (38.805)	0.1797*** (45.030)	0.3169*** (75.881)	0.1909*** (44.334)	0.1435*** (13.100)	0.2856*** (28.687)	0.2300*** (21.262)
Non-technology innovators	0.0959*** (13.777)	0.0963*** (13.773)	0.0690*** (9.998)	0.2246*** (27.565)	0.0643*** (13.872)	0.0634*** (13.577)	0.0296*** (6.103)	0.1864*** (34.178)	0.1508*** (38.836)	0.1298*** (32.104)	0.0881*** (36.600)	0.1877*** (74.595)	0.1724*** (66.459)	0.0859*** (14.351)	0.2172*** (56.344)	0.1338*** (21.500)
Barrier-related non-innovators	0.1771*** (19.798)	0.1591*** (17.738)	0.2443*** (27.567)	0.3354*** (35.879)	0.1911*** (41.942)	0.1786*** (38.832)	0.2101*** (43.971)	0.3065*** (57.075)	0.3512*** (123.198)	0.3390*** (166.642)	0.2851*** (106.642)	0.4681*** (167.248)	0.3939*** (136.510)	0.2634*** (49.489)	0.2648*** (52.307)	0.3076*** (88.325)
Constant	0.7588*** (8.683)	0.6534*** (7.459)	0.9703*** (11.200)	1.0665 (1.625)	0.6534*** (10.188)	0.6205*** (9.585)	0.7171*** (10.661)	0.7711*** (19.224)	0.5474*** (17.680)	0.6747*** (22.411)	0.5431*** (18.704)	0.4104*** (13.501)	0.5283*** (16.810)	0.6466*** (7.443)	0.7164*** (8.064)	0.8861*** (14.062)
Observations (weighted)	24030	24035	24046	24046	55927	55927	55927	55927	216512	216512	216512	216512	216512	51183	51183	51183
pseudo R2	0.059	0.066	0.072	0.125	0.041	0.039	0.044	0.091	0.083	0.083	0.070	0.156	0.109	0.063	0.156	0.080
II	-1.0995	-1.1090	-1.0812	-1.0790	-2.3985	-2.4808	-2.6652	-3.1380	-1.35357	-1.29280	-1.21461	-1.31375	-1.37965	-3.2276	-3.3905	-3.4656

Source: CIS 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, Luxembourg, 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.

Annex C:

C.1 Industry classification (Peneder 2010)

Peneder (2010) constructs an innovation classification based on Community Innovation Survey (CIS) micro data for 21 countries. He classifies firms on the basis of entrepreneurship types and technological regimes. He identifies five industry groups according to their innovation intensity and the underlying technological regime:

High innovation intensity: NACE 29, 30, 31, 32, 33, 72, 73

Medium-high innovation intensity: NACE 17, 23, 24, 25, 26, 27, 34, 35, 64

Medium innovation intensity: NACE 20, 21, 28, 36, 62, 65, 74

Medium-low innovation intensity: NACE 10, 11, 15, 16, 22, 40, 41, 66

Low innovation intensity: NACE 14, 18, 19, 37, 51, 60, 61, 63, 67.

C.2 Basicness and cumulativeness of R&D

We control for the fact that innovations in different sectors have different knowledge characteristics by considering the cumulativeness and basicness of innovation at the firm level based on information sources (see for a similar concept Cassiman and Veugelers, 2002). Assuming that more basic innovations require more input of 'new' and 'basic' knowledge from universities and research institutes, and that cumulative innovations are characterised by information internal to the firm. The definitions of basicness and cumulativeness of R&D at the firm level are:

1. Basicness of R&D: ratio between
 - a. sum of scores of importance [number between 1 (unimportant) and 5 (crucial)] of following information sources for innovation process: (a) universities and (b) public research institutes; and
 - b. sum of scores of importance of following information sources for innovation process [number between 1 (unimportant) and 5 (crucial)]: (a) Suppliers of equipment, materials, components, or software, (b) customers or clients and (c) Competitors or other enterprises in your sector, and (d) Conferences, trade fairs, exhibitions.
2. Cumulativeness of R&D: ratio between
 - a. sum of scores of importance of following information sources for innovation process [number between 1 (unimportant) and 5 (crucial)]: Within your enterprise or enterprise group; and
 - b. sum of scores of importance of following information sources for innovation process [number between 1 (unimportant) and 5 (crucial)]: (a) Suppliers of equipment, materials, components, or software, (b) customers or clients and (c) Competitors or other enterprises in your sector, (d) Conferences, trade fairs, exhibitions, (e) universities, and (f) public research institutes.

In the regression analysis we use industry averages at the Nace 2-digit level. The averages are calculated using only data for innovative firms. This implies, however, that the two indicators capture in addition also unobserved industry (Nace 2-digit) characteristics. This is the reason why we use these variables only as controls.