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Distinguishing persistent from occasional innovators: the case of Polish manufacturing firms

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Abstract

This paper uses obstacles to innovation to investigate the heterogeneity of Polish innovating firms. Based on the frequency with which they introduce innovations, and using data from both CIS4 (for 2002-2004) and CIS5 (2004-2006), the paper distinguishes between two groups of innovating firms: those which introduced innovation in both periods covered by both CIS (called persistent innovators) and those which introduced innovation either in CIS4 or CIS5 (occasional innovators). Two steps analysis covering probit and biprobit models is introduced. The paper shows there is a discrepancy between the number of actual obstacles to innovation faced by firms and the number of obstacles perceived by managers of firms (subjective obstacles). It argues that the impact of obstacles to innovation on the innovation activities of occasional innovators differs from that of persistent ones. Obstacles to innovation reveal weaknesses in the innovation activities of persistent innovators. In the case of occasional innovators, some obstacles prevent firms from introducing innovation. The paper supports the view that the way firms innovate and the frequency with which they use knowledge resources is linked to the obstacles to innovation they face and their impact on innovation activities.

1. Introduction

Innovation is a central concept to economic growth and is recognised as a source of sustained competitive advantage to firms. Innovative firms are heterogeneous in many ways. As there are many factors that determine innovation, the research tends to differentiate the various modes of innovation that firms introduce.

Empirical analysis shows that not all firms introduce innovation regularly and this raises the question of the reasons for this. Do regularly innovating firms differ from non-regularly innovating firms with respect to sources of knowledge and impediments to innovations? This question seems relevant to the discussion on heterogeneity in innovation activities across innovative firms and the differences among them. It also refers to the 'barriers approach' to innovation activities, which refers to obstacles to innovation. Although research within this approach (D'Este et al. 2009) shows that there are differences between innovating and non-innovating firms with respect to their perception of obstacles to innovation, it treats all innovative firms as an undifferentiated group. Only a few contributions on obstacles to innovation refer to the heterogeneous nature of innovative firms.

This paper argues that by looking at a group of innovative firms in greater detail, we may gain a richer picture of their heterogeneous nature. This concerns not only knowledge sources and actual versus perceived (subjective) obstacles to innovations, but also the impact of innovation obstacles on firms which are shifting from innovating to non-innovating. Using the Community Innovation Survey (hence forth CIS) data for two periods: 2002-2004 (CIS4) and 2004-2006 (CIS5), we introduce a taxonomy that is based on the frequency of engagement of firms in innovation activities measured by innovation output. Two groups of innovators were selected: the group that innovates continuously (introduced commercialised innovation in both CIS4 and CIS5) and the other that innovates on occasion, that is either in the first (CIS4) or second (CIS5) period. The second group of innovators has two subgroups: firms which introduced commercialised innovation only in the first period and the ones that introduced it only in the second period.

Significantly fewer Polish manufacturing firms introduced commercialised innovation than firms in the European Union incumbent countries. Also, the share of innovative firms out of the total number of firms has been continuously dropping; it went from 25.6 % in 2004 to

21.3% in 2008. Little is known about the differentiation of innovative firms. In order to get a richer picture of firms that introduce innovation, it is useful to gain knowledge on obstacles to innovation that firms face, distinguishing between firms that introduce innovation regularly versus non-regularly. This knowledge is also important for the government as it is helpful to identify which innovation obstacles inhibit the innovation activities of firms.

Using the obstacles approach that also takes into account the sources of knowledge that firms use, this paper refers to the diversity of innovation-active firms. Its aim is threefold: First, to distinguish and characterise those innovating firms that engage in innovation activities continuously from those that only innovate on occasion; Second, to show differences between the two groups of innovators with respect to perceived (subjective) and actual obstacles to innovation; Third, to present the impact of obstacles to innovation activities on the two groups of innovators. In the paper, we also intend to select two types of innovation obstacles: those that prevent innovation, i.e. are responsible for firms shifting from innovating to non-innovating, and those which reveal weaknesses in the knowledge sources of innovative firms.

The paper is structured as follows. Section 1 reviews the contribution of the literature on the heterogeneity of innovative firms and on the relationship between obstacles to innovation and firms' characteristics and knowledge sources. Section 2 characterises the two groups of innovators. In Section 3, an econometric model is used to explore the factors affecting the probability of perceiving the obstacles as significant. Section 4 discusses the results of the model for both groups of innovators. Evidence on the perception of the obstacle to innovation is reported. Differences between persistent and occasional innovators are highlighted. The impact of innovation obstacles on innovation activities is presented in the next section. The summary and conclusions wrap up the paper.

2. Overview of the literature

Innovation is a complex phenomenon, and firms differ in terms of innovation sources, orientation and intensity. Micro data show a high degree of heterogeneity of innovation behaviour among individual firms. This complexity leads to various taxonomies of firms in terms of innovation capabilities, strategies, ways of creating innovation and modes of

innovation. Although the classifications of innovative firms introduced below are based on factors that are conducive to innovation, they differ in many respects, especially criteria of classifications, methodology introduced and scope of analysis. At least three types of classification can be selected.

The first type has a dichotomous character. Using different criteria, various types of firms are selected. The division of firms according to learning process into cumulative (those which adopt an internal learning-by-searching strategy) and non-cumulative (aimed at absorbing external sources of knowledge) shows two types of specific innovative strategies (Llerena, Oltra 2002). This classification has a great deal in common with the division of firms into those generating innovation and those adopting innovation (Damanpour and Wischnevsky, 2006). The former are primarily producers or suppliers of innovation. The latter are preponderantly users of innovation. Also Jensen et al. (2007) contrast two modes of innovation. The first one (Science, Technology and Innovation) relies on the production and use of codified scientific and technical knowledge, while the other (Doing, Using and Interacting) is based on the informal process of learning and experiences. In the literature there are also many classifications which are an extension of the distinction between innovators (creative firms) and imitators. The last category is diversified. It covers incremental innovators, followers,[1] traditionals,[2] (Avermaete et al., 2004) and technology adopters (Peneder 2010). Innovation intensity is also used to differentiate three categories of innovative firms: intensive innovators, persistent innovators and innovators with one innovation (occasional) (Lehtoranta 2005).

The second type of classification is based on and extends Pavitt's (1984) typology, which is a 'standard' point of reference in much of the literature on innovation heterogeneity (Jong, de, and Marsili, 2006, Peneder 2003).

The third type of classification of innovative firms that represent different strategies of innovation uses exploratory factor analysis and cluster methodology (Tiri, Peeters and Swinnen; Hollenstein, 2003; Clausen and Verspagen, 2008; Srholec and Verspagen, 2008; Wziątek-Kubiak, Balcerowicz, Pęczkowski 2009a, 2009b).

[1] They spend up to 1% of their annual sales on R&D

[2] They do not perform R&D activities themselves; however they introduce new or substantially modified product or processes.

These classifications of firms confirm the heterogeneity of innovative firms in terms of the knowledge inputs they use. On the other hand, research shows that various impediments, obstacles or barriers to innovation are important factors which prevent firms from engaging in innovation activities or limit the success of innovation activities. However analyses on barriers, impediments or obstacles to innovation do not refer to the heterogeneity and innovation strategies of innovative firms. They focus on different issues like the impact of differences among innovative firms' characteristics and sources of innovation on the perception of obstacles, impact of obstacles on innovation activities or relationship between a firm's innovation activities and the importance that firms attach to obstacles. This approach has treated all innovative firms as an undifferentiated group (e.g. Leitao et al. 2007; Daniel and Grimshaw, 2002; Tourigny and Lee 2004; Baldwin and Lin, 2002; Iammarino et al., 2006). Only a few contributions on obstacles to innovation refer to the heterogeneous nature of innovative (Pihkala et al. 2002; Blanchard et al. 2010) and non-innovative firms (D'Este et al. 2008, 2009).

Most of the contributions on obstacles to innovation focus on the relationship between impediments to innovation and various firm characteristics such as a firm's size, technology intensity, the competitive pressure of the environment and type of ownership. The research shows that these characteristics matter for obstacles to innovation as perceived by the firms. Many contributions show that firms face different obstacles to innovation depending on their size. Different analyses find mixed results regarding the perception of obstacles according to a firm's size. For example according to Baldwin and Lin (2002), and Tourigny and Lee (2004), large firms are more likely to report cost-related and organization-related obstacles to innovation than small firms. This is in opposition to Mohnen and Rosa (1999), Hyytinen and Toivanen (2005) and Immmarino at al (2007).

In the sectoral approach to innovation, i.e. technology intensity or the technological environment within which firms operate, obstacles to innovation are also considered. This approach posits that firms in low and medium low technology industries are less likely to face impediments to innovation than those in high and medium high technology industries (Baldwin and Lin, 2002; Tourigny and Lee, 2004).

Competition is another factor that is included in the analysis of obstacles to innovation. Baldwin and Lin (2002), Mohnen and Rosa (1999) and Tourigny (2004) show a positive and significant relationship between obstacles to innovation and competition. This suggests that

the obstacles to innovation are strongest when competition is at its highest level or that the most innovative firms are those which perceive impediments to innovation most strongly.

There are very few analyses on differences in perception of innovation between domestic and foreign firms. Immmarino at al. (2007) show that foreign-owned and Italian-owned multi-national corporations (MNC) operating in northern and central Italy have different perceptions of obstacles to innovation. Foreign-owned firms are more aware of the problems encountered when innovating than domestic ones.

There is also research on the relationship between innovation obstacles and a firm's propensity to innovate (Blanchard et al. 2010), the degree of innovation (Pihkala et al. 2002), and between obstacles and innovation factors (Canijels and Verspagen, 2001).

3. Data and methodology

This study uses firm level data from both the Fourth and Fifth Community Innovation Survey (CIS4 refers to the period 2002-2004 and CIS5 to period 2004-2006) for Polish manufacturing firms that were released by the Central Statistics Office. The dataset for CIS6 does not have questions related to obstacles to innovation. CIS4 and CIS5 data for Poland are not published by Eurostat. Neither it is available at the Eurostat site in Luxemburg[3] at a micro-aggregated level.

Our analysis covers a 5 year period, 2002-2006. This was a growth phase in the Polish economy so changes in innovation activities and the perception of innovation obstacles of analysed firms were not influenced by changes in the economic cycle. As the period under consideration is rather short and our analysis shows small changes in performance in 2006 as compared to 2004, in the paper we only present data for 2006.

The focus of the paper is exclusively on innovative firms. Although the question on obstacles to innovation was addressed to both innovating and non-innovating firms, the questions on

[3] Where non-aggregated individual responses can be used for scientific studies

knowledge sources were answered by innovative firms exclusively. We are not able to consider and analyse non-innovating firms in the period under consideration as the CIS does not cover data on their knowledge inputs. This impacts the way we classify innovative firms. We use the CIS definition which says that an innovative firm is a firm that introduced a new or significantly improved product (either a good or service) or any new or significantly improved processes for producing or supplying products to the enterprise in the period covered in a given CIS. This definition is consistent with the standard definition of innovation as recommended by the Oslo Manual (OECD, 2005). However as we consider CIS4 and CIS5, innovation firms are those that introduced new or significantly improved products or processes in either CIS4 or CIS5.

Using weighted data, our analysis examined private (domestic and foreign owned) manufacturing firms that were included in both CIS4 and CIS5 and excluded firms that were included only in one of the two CIS. Our panel covered 3,600 manufacturing firms that were innovators either in both periods (both CIS) or only over one period. Based on the criteria of the frequency of introduction of innovation, we introduced a taxonomy of Polish innovating firms. We call those firms that introduced commercialized innovation in both periods persistent innovators. The firms that introduced commercialized innovation in one of the periods, either in 2002-2004 or in 2004-2006 are called occasional innovators. Their population covers two subgroups: innovating and non-innovating firms in a given period. Our panel covered 2,371 permanent and 1,229 occasional innovators (Table 1).

In the paper, the size of the firms is measured by 3 binary variables capturing the number of employees: 20-49 employees (small firms), 50-249 employees (medium) and more than 249 (large). In terms of technology intensity, firms are classified into four groups based on the OECD definition: low technology, medium-low technology, medium-high and high technology. As a proxy of the internationalization of production reflecting differences in competitive pressure, we used the share of export of innovative products. Based on these criteria, we selected non-exporting and exporting firms. The latter are divided into two groups: the ones whose share of exported innovative products is below 10% and the ones in which the share is above 10%. Only private firms are analysed in the paper and we check for domestic and foreign owned firms.

On characterizing the innovative activities of the firms, we distinguished between five different knowledge inputs into the innovation process and their sources. First, we

considered the continuity of R&D activities which reflects the differences in the frequency of in-house R&D. Because firms can also acquire technology externally, we also considered the acquisition of other (intangible) external knowledge (purchase or licensing of patents and not-patented inventions, know-how, and other types of knowledge from other enterprises and organisations) and cooperation in product and process innovation within the firm or its group. As the new member states' innovation activities are based mostly on other external sources of innovation (Bitzer et.al. 2007; Leon-Ledesma, 2005), we considered types of partners (domestic firms, foreign firms and R&D institutions) while developing innovation, partners in cooperation in innovation activities, and other sources of market information. As a result, we covered forward linkages to customers, backward linkages to suppliers, horizontal linkages to competitors and linkages to R&D institutions.

We investigated all eleven obstacle items (Table 3) listed in CIS4 and CIS5: economic obstacles (innovation costs too high and two financial obstacles - lack of funds within an enterprise or group, lack of finance from sources outside an enterprise), knowledge obstacles (lack of qualified personnel, lack of information on technology and markets, difficulty in finding cooperation partners for innovation), market obstacles (market dominated by established enterprises and uncertain demand for innovative goods) and reasons not to innovate (no need due to prior innovations and no need because of lack of demand for innovations). We considered only obstacles that respondent firms perceived as important and very important (2 and 3 on the Likert scale).

A two-step procedure, which included both obstacles to innovation and explanatory variables, was implemented. At first, we intended to identify differences in sensitivities to perception of innovation obstacles conditional on four firm characteristics and on five types of knowledge sources that firms used. To answer this question, we introduced an econometric analysis based on a probit model. It covered eleven independent equations which estimate the eleven obstacles separately. Obstacles were binary: 1 - if firms perceived the barrier as important or very important; 0 - if the importance was low or if a barrier was not important. A dependent variable related to the perception of the obstacles to innovation as indicated by firms. Independent variables were characteristics of firms and innovation inputs used. The same set of independent variables was used in the equations. The reference categories for the analysis are presented in the Appendix (Table A1). The general specification of the probit model is as follows:

$y_j^* = \alpha_j + x\beta_j + u_j$, j=1,...,11

y_j^* are the latent variables corresponding to the probability that a firm perceives j-th barrier as important, x is a vector of explanatory variables, αj and βj are coefficients of j-th equation, uj are disturbances of j-the equation. We use the same explanatory variables for all equations. Variables y_j^* are unobserved. We observe binary variables yj, where

$y_j = 1 \; if \;\; y_j^* > 0$ and $y_j = 0$ otherwise

We assume that the disturbances have a multivariate normal distribution with mean vector 0 and covariance matrix with diagonal elements equal to 1.

In the next step we intended to show if, how and which obstacles impact the shift of firms between the innovating and non innovating group. So we introduced a bivariate probit model with the goal of identifying the obstacles that prevent innovating.

The bivariate (or multivariate) probit model is a natural extension of the probit model when we have more than one equation with correlated disturbances. The equations are linked only by their disturbances in the same way as in the seemingly unrelated regression models. We estimate a bivariate probit model in which two equations are estimated simultaneously.

In our case, the explanatory variables are identical in both equations. There are eleven obstacles of innovation and each regressor is a binary variable. The first equation identifies the dependent variable in both the 2002-2004 and 2004-2006 periods. In the second equation, the dependent variable identifies occasional innovators which introduced product or process innovation only in 2002-2004 (first model) and only in 2004-2006 (second model).

The general specification of the bivariate probit model is as follows:

$y_1^* = \alpha_1 + x\beta_1 + u_1$

$y_2^* = \alpha_2 + x\beta_2 + u_2$,

where y_1^* and y_2^* are the unobserved latent variables corresponding to the probability that a firm is a permanent innovator (in the first equation) or introduced innovations only in one of the considered periods, respectively in 2002-2004 and 2004-2006 (in the first equation).

$y_1 = 1$ if $y_1^* > 0$ and $y_1 = 0$ otherwise

$y_2 = 1$ if $y_2^* > 0$ and $y_2 = 0$ otherwise

We assume that the disturbances (u_1, u_2) have a bivariate normal distribution and

$E(u_1) = 0$, $E(u_2) = 0$

$Var(u_1) = 1$, $Var(u_2) = 1$

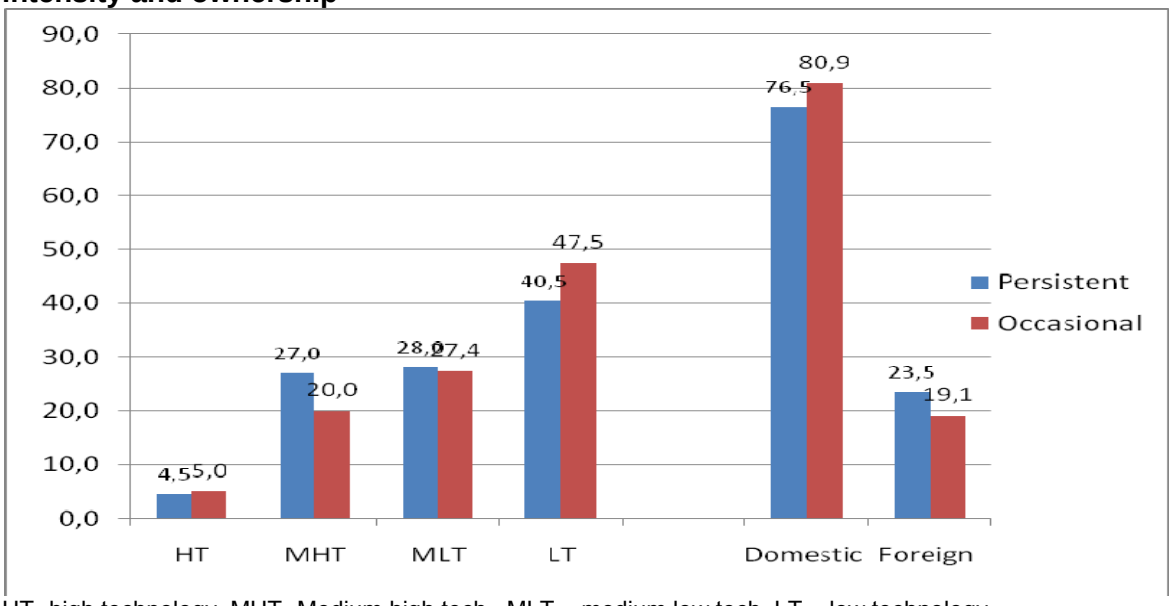
and covariance $Cov(u_1, u_2) = \rho$

The method of estimation is the maximum-likelihood method realized, for example, by the procedure biprobit in STATA11 (2009).

4. Differences in characteristics between persistent and occasional innovators

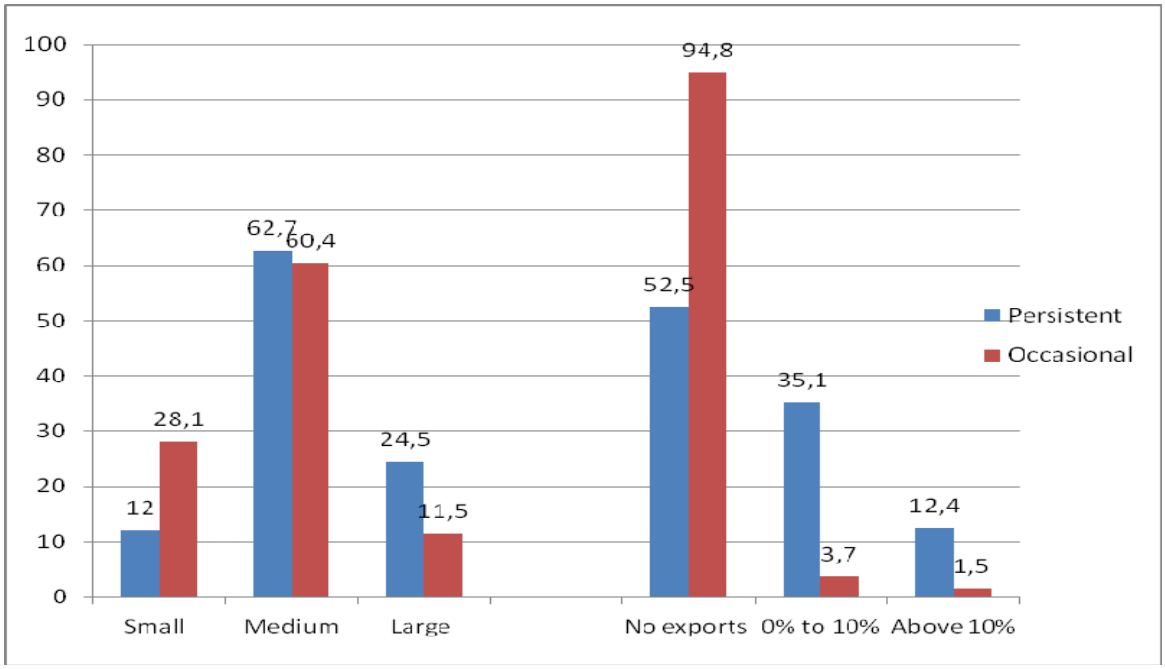
In this section we compare persistent and occasional innovators with respect to their characteristics and knowledge sources. There are slight differences in characteristics between the two types of innovators. In term of ownership of firms, the differences are very small. Greater differences are observed in terms of size and technology intensity and the greatest differences can be seen in the export intensity of innovative goods.

Fig. 1. Comparison of occasional against persistent innovators, by technology intensity and ownership



HT- high technology, MHT- Medium high tech., MLT – medium low tech, LT – low technology

Fig. 2. Comparison of occasional against persistent innovators, by size and export intensity of innovative products



The sample is dominated by domestic firms. The share of foreign owned firms in the population is only slightly larger than in the case of occasional ones (Fig. 1). The share of medium-sized firms in both groups of innovators is similar. However the proportion of large firms in the persistent innovator population is two times larger than in the occasional innovator group. The opposite is true in the case of small firms. The differences between permanent and occasional innovators in terms of technological intensity are not great. These differences concern the share of medium-high and low technology intensive industries. A slightly larger share of medium high technology industries is typical for persistent innovators. The opposite occurs in the case of low technology industries. The largest difference between the two groups of innovators concerns the export intensity of innovative products (the share of innovation products in export sales). Only a few occasional innovators export innovative products, while every other permanent innovator does. The share of persistent innovators whose innovation intensity of exports share exceeds 10% is eight times larger than the occasional ones (Fig.2). Persistent innovators operate under much stronger competitive pressure than occasional innovators. The latter focus on the sales of innovative products on the domestic market.

Overall the population of persistent innovators is characterised by a slightly higher share of large, foreign-owned and medium-high technology industry firms than the population of occasional innovators. The first group of innovators is also export oriented while the occasional innovators focus on domestic market sales.

The small (except for export exposure, where the difference is substantial) differences in characteristics between the two groups of firms are accompanied by significant differences in the frequency of the use of knowledge sources.

As data on the share of in-house R&D in sales revenues have not been disclosed to us, we used the continuity of in-house R&D activities in a firm as a proxy for R&D intensity. Persistent innovators are much more prone to conducting in-house R&D activities (Table 1) and their R&D intensity is possibly higher. Although only 14% of persistent innovators regularly conduct in-house R&D activities, this proportion is still three and half times greater than of the percentage of occasional innovators who conduct R&D activities. Persistent innovators more frequently cooperate within a firm or a group while developing process and namely product innovation (Table 1).

Surprisingly, the more frequent involvement of persistent innovators in in-house R&D activities accompanies the less frequent acquisition of intangible external knowledge. It seems that the frequent use of external knowledge by occasional innovators substitutes for rather than complements conducting their own research. In-house R&D activities do not complement the above-mentioned intangible external knowledge. Our results are not in accordance with the existing literature, which presents arguments for complementarity between in-house R&D and external knowledge (Cassiman and Veugelers 2002).

Research studies (Veugelers and Cassima,1999; Fabrizio, 2009; Mazzanti, Mancinelli, 2007) provide strong evidence for R&D active firms to be more active in using various types of external sources of knowledge. Persistent innovators that are more often engaged in in-house R&D activities also more frequently use various external knowledge sources, including participating in networking. Their expenditure on R&D is complementary to their networking activities. In terms of innovation activities, persistent innovators cooperate five times more frequently with other firms within their group and with suppliers of equipment and materials, competitors, and/or scientific institutions than occasional ones. Persistent innovators more frequently use market information on innovation activities than occasional ones (Table 1).

Table 1. Differences in knowledge sources between permanent and occasional innovators in 2006

	Permanent		Occasional		Panel	
	No of firms	**% of permanent population**	**No of firms**	**% of occasional population**	**No of firms**	**% of panel population**
R&D activities						
In-house R&D continuous	334	14.1	47	3.8	381	10.6
R&D on occasion	615	25.9	176	14.3	791	22.0
None- R&D activities	1423	60.0	1006	81.9	2429	67.5
Acquisition of other external knowledge	471	19.9	799	65.0	1270	35.5
Institutions and firms cooperating in developing product innovations						
Mainly your enterprise or enterprise group	1525	64.3	297	24.2	1822	50.6
Your firm together with other firms or domestic scientific institutions	194	8.2	27	2.2	221	6.1
Your firm together with other firms and /or foreign scientific institutions	65	2.7	10	0.8	75	2.1
Domestic scientific institution	7	0.3	2	0.2	9	0.3
Mainly foreign enterprises and /or scientific	23	1.0	9	0.7	32	0.9
Mainly other domestic firms	21	0.9	13	1.1	34	0.9
Institutions and firms cooperating in developing process innovations						
Mainly your enterprise or enterprise group	1421	59.9	580	47.2	2001	55.6
Your firm together with other firms or domestic scientific institutions	357	15.1	143	11.6	500	13.9
Your firm together with other firms and /or foreign scientific institutions	131	5.5	28	2.3	159	4.4
Domestic scientific institution	21	0.9	6	0.5	27	0.7
Mainly foreign enterprises and /or scientific	79	3.3	37	3.0	116	3.2
Mainly other domestic firms	155	59.9	107	47.2	262	7.3
Cooperation partners in innovation activities						
Other firms within your firm group	420	17.1	44	3.6	464	12.9
Suppliers of equipment. materials. components. or software	979	41.3	104	8.5	1083	31.1
Clients and /or customers	658	27.8	58	4.7	716	19.9
Competitors or other firms in your sector	281	11.9	27	2.2	308	8.6
R&D sector*	593	25	593	4.2	645	17.9
Sources of market information on innovation						
Other firms within your firm group	1340	56.5	229	18.6	1569	43.6
Suppliers of equipment. materials . components and software	383	16.2	107	8.7	490	13.6
Clients or customers	744	31.4	133	10.8	877	24.4
Competitors or other firms in firm sector	412	17.4	101	8.2	513	14.3
R&D sector*	276	11.6	65	5.3	341	9.5
Other sources**	667	28.1	136	11.1	803	22.3

*including consultants, commercial lab. private and government, universities and higher education institutions
**Conferences, trade fairs, exhibitions, scientific journals and trade/technical publications, professional and industry associations

In innovation strategy, occasional innovators focus on process innovation while permanent ones focus on product innovation. Differences in innovation strategy impact the differences in frequency in cooperation with respect to product and process development. 47.2% of occasional innovators cooperate within a firm or a group of firms while developing process innovation and 24.2% cooperate with a firm of group of firms while developing product innovations (Table 1). Meanwhile, for persistent innovators, the figures are 59.9% and 64.3%, respectively. 11.6% of occasional innovators cooperate with other firms while developing process innovations and 2.2% while developing product innovations (in the case of persistent innovators - 15.1% and 8.2% respectively).

Summing up, persistent innovators are externally oriented (use of network) and focus on product innovation while occasional innovators focus on process innovation.

5. Differences in observed and actual obstacles to innovation between two groups of innovators

In this section we introduce two interpretations of problems that firms encounter while pursuing innovation activities. Firstly, we investigate eleven impediments that managers of innovative firms recognise as important and very important (Table 2). In the CIS4 and CIS5, firms are asked to "grade the importance of any hampering factors to technological innovation activity which the enterprise has experience". This means that the obstacle variable used is qualitative and represents the evaluation of the firms to the *perceived* obstacles to innovation i.e. factors hampering innovation activities. As Iammarino et al. (2007) put it, the CIS question does not indicate a direct causal effect between the perception of the obstacle and the choice of introducing or not introducing an innovation. The evaluation of the problems innovative firms have overcome in carrying out innovation activities (which are revealed in the CIS questionnaires) does not indicate whether these problems represented *actual* obstacles (barriers), which would prevent innovative firms from pursuing innovative activities or forced them to abandon their innovative activities. That is why we intend to show whether observed impediments represent actual obstacles to innovation. We calculate the probability of perceiving the obstacles conditional on knowledge sources and characteristics of both groups of innovators (Appendix Tables A2 and A3).

Table 2. Frequency of firms' perception of obstacles to innovations according to descriptive variables (% of firms meeting at least one barrier) in 2006

	Permanent		Occasional		Total	
	No. of firms	% of permanent population	No. of firms	% of occasional population	No. of firms	% of panel population
a) Lack of funds within firm or group	1394	58.8	713	58.0	2107	58.5
b)Lack of finance from sources outside your firm	1220	51.5	656	53.4	1876	52.1
c) Innovation costs too high	1591	67.1	786	64.0	2377	66.0
d) Lack of qualified personnel	803	33.9	437	35.6	1240	34.4
e) Lack of information on technology	634	26.7	392	31.9	1026	28.5
f) Lack of information on markets	570	24.0	326	26.5	896	24.9
g) Difficulties in finding cooperation partners	657	27.7	416	33.8	1073	29.8
h) Market dominated by established firms	1025	43.2	520	42.3	1545	42.9
i) Uncertain demand for innovative goods or services	1210	51.0	567	46.1	1777	49.4
j) No need due to prior innovation	424	17.9	265	21.6	689	19.1
k) No need because of no demand for innovations	487	20.5	317	25.8	2107	22.3

Firms rated three economic innovation obstacles (a-c, Table 2) as both very important and important among all obstacle items. This is not surprising as financial problems are particularly acute in innovation activities due to some of their inherent characteristics (Hall 2002; Mohen et al. 2008). Three economic obstacles and the uncertain demand for innovative goods were perceived by every other firm in both groups of innovators. However the excessive costs of innovation were cited even more often, notably in the case of persistent innovators. The obstacles that follow are: market dominated by established firms and lack of qualified personnel. In sum, economic obstacles and market obstacles were most strongly observed by innovation active firms. Knowledge obstacles and 'no need to innovate' obstacles were less frequently observed.

The two types of innovators differ in the frequency of perception of innovation obstacle items, both within a given set of obstacles (obstacle items), and in terms of sets of obstacles. Persistent innovators perceived only 4 out of 11 obstacle items as important more frequently than occasional ones. A larger number of persistent innovators perceived excessive innovation costs and uncertain demand for innovative goods as significant impediments to

innovation. Occasional innovators perceived 7 out of 11 obstacles items as significant more frequently than permanent ones They more strongly perceived market barriers. Occasional innovators more strongly perceived both knowledge and 'no need to innovate' obstacles.

The literature review shows that characteristics of firms and different knowledge sources have an impact on the differences in sensitivities to the perception of innovation obstacles.
The sensitivity to perception of most innovation obstacles of large innovators is lower than the sensitivity to perception of medium-sized innovators. The smaller the firm, the larger the probability that it perceives obstacles to innovation. A higher share of large firms in the population of persistent innovators accompanies a lower probability of perceiving most of obstacles. The higher the technological intensity of an industry, the probability of perceiving of a greater number of obstacles increases. However, persistent innovators belonging to high technology and medium-high technology industries are sensitive to the perception of the same obstacles which are different from their occasional counterparts (Appendix, Table A2 and A3).

Exporters of innovation products are more prone to perceiving obstacles to innovation than non-exporters. The population of persistent innovators, in which every other firm is engaged in the export of innovation products, tends to perceive more obstacles than occasional innovators, who focus on domestic market. The higher the export share, the more frequently the sensitivity to perception of obstacles drops. A lower innovation intensity of export accompanies an increase in sensitivity to the perception of innovation obstacles.

Foreign versus domestic ownership of firms impacts the sensitivity to perception of innovation obstacles. When compared with domestic firms, foreign-owned firms operating in Polish manufacturing have a decreasing sensitivity to the perception of innovation obstacles. This is in line with the results of the analysis conducted by Immarino et al. (2007) on northern and central Italy. In our population of firms the sensitivity to perception of obstacles of the foreign owned occasional innovators decreases more than in case of their persistent counterparts.

Summing up, the more competitive the environment, the more obstacles are perceived by innovative firms. As the export of innovative products acts as a factor that diminishes the sensitivities to the perception of innovation obstacles, it differentiates the sensitivity to the perception of obstacles between persistent and occasional innovators. The larger the firm,

the lower its sensitivity to the perception of obstacles. However the sensitivity to the perception of innovation obstacles of large persistent innovators decreases more than that of their occasional counterparts. In respect to the technology intensity, there are large differences in sensitivity to perception of innovation obstacles between persistent and occasional innovators as well as between firms operating in different sectors. Ownership matters for sensitivity to perception of innovation obstacles as the perception of obstacles by foreign owned firms diminishes as compared to domestic owned firms. However, the probability of perceiving innovation obstacles in occasionally innovating foreign owned firms is lower than that of their permanently innovating counterparts.

Persistent innovators

Focusing on 16 external and 4 internal knowledge sources that panel innovators use, we present commonalities and differences in sensitivity to perception of obstacles between two groups of innovators conditional on these sources.

We start with four types of internal knowledge sources: continuous and irregular in-house R&D activities as well as cooperation in innovation activities within a firm and its group while developing product and process innovation. Persistent innovators that use different internal knowledge sources than occasional innovators are sensitive to the perception of different innovation obstacles. Sensitivity to the perception of innovation obstacles reduces only for persistent innovators which carry out continuous R&D activities. They are less sensitive to the perception of two financial obstacles and difficulties in finding cooperation partners. Conversely, engagement in both irregular R&D activities and intra-firm and intra-group cooperation while developing product and process innovation increase sensitivity to the perception of obstacles. Firms that are engage in in-house R&D activities irregularly are more prone to perceive three obstacles: two information ones and a lack of qualified personnel. Firms engaged in cooperation within the firm or its group while developing both product and process innovation are more sensitive to obstacles related to the dominant position of an established firm and uncertain demand for innovative goods.

Firstly, external knowledge sources reveal more obstacles to innovation than internal ones. The use of these sources is more likely to increase sensitivity to the perception of obstacles to innovation.

Secondly, the sensitivity to the perception of obstacles increases most frequently while persistent innovators cooperate in developing product innovation and cooperate in innovation activities. It increases less frequently when they use market information on innovation and cooperate in process innovation with different partners.

Thirdly, different forms of cooperation reveal sensitivity to the perception of different innovation obstacles. Cooperation with other firms while developing product innovation enhances the incidence of three obstacles linked to the excessive costs of innovation, the dominant position of an established firm and uncertain demand. In opposition to this, the cooperation of persistent innovators while developing process innovation reduces the incidence of two obstacles: no demand for innovation goods and lack of market innovation. It increases this sensitivity to only one obstacle– lack of skills of personnel.

Fourthly, different obstacles are revealed in cooperation in innovation activities with different partners. For example persistent innovators that cooperate in innovation activities with suppliers are more prone to perceiving difficulties in finding a cooperation partner and lack of technological information, while with customers – a lack of qualified personnel and the dominant position of an established firm. Changes in sensitivity to the perception of a given innovation obstacle depends on the partner of market information. For example the dominant position of an established firm is perceived as a stronger impediment when a firm uses market information from competitors. However, the sensitivity to this obstacle lowers when information stems from customers or suppliers.

All in all, most of the external knowledge sources that persistent innovators used increase the probability of perceiving innovation obstacles, while only a few sources lower it. Sensitivity to the perception of some innovation obstacles, for example the dominant position of established firms on an innovative goods market are enhanced by many knowledge sources, while others (lack of finance within a firm) by a few ones. Surprisingly although over 58% (Table 2) of panel firms recognised a lack of finance within a firm as a significant obstacle, it is not enhanced by any knowledge sources (Appendix Table A2). The engagement of persistent innovators in continuous in-house R&D activities even reduces the incidence of this obstacle. In other words no knowledge sources out of the 19 that persistent innovators used increase the sensitivity to perception of this obstacle and a few lower this probability. If no knowledge source reveals a given obstacle it should not impede or should not be treated as an important or very important obstacle to innovation activities. And on the

contrary, if some knowledge sources increase the sensitivity to perception of a given obstacle we can expect that this obstacle is an actual obstacle.

We compared the frequency of firms that face a given obstacle to innovation conditional on knowledge sources with the frequency of respondents' perception of a given obstacle as important (Table 2). This allowed us to find out if the frequency of perceiving an obstacle is overestimated or underestimated by the CIS respondents. A higher frequency of perceived (by respondent) than actual (revealed by knowledge sources) obstacles suggests that firms face fewer actual obstacles to innovation than they think**.**

In most cases the frequency of persistent innovators' perception of actual obstacles is lower than suggested by the CIS respondents. For example according to descriptive statistics, 51% of persistent innovators face excessive costs of innovation and recognised this as an important or very important obstacle to innovation. The share of persistent innovators that use three knowledge sources that enhance the sensitivity to perception of this obstacle accounts for 26% of the total number of persistent innovators. The share of firms that use two knowledge sources which lowers the sensitivity to the perception of this obstacle accounts for 12.6%. As much fewer firms actually face excessive costs of innovation than the descriptive statistics suggest, many persistent innovators overestimate the frequency with which they face this barrier. In addition to excessive costs, we have found that overestimation also concerns other obstacles, like three economic obstacles, lack of qualified personnel, no need to innovate because of lack of demand for innovations and no need to innovate because of prior innovation. Some knowledge factors lower the sensitivity to perception of these obstacles.

Occasional innovators

With respect to the use of internal and external sources of knowledge and sensitivity to perception of obstacles to innovation conditional on knowledge sources, occasional innovators differ from persistent ones quite considerably.

The internal sources of knowledge that occasional innovators use reveal obstacles less frequently than in the case of persistent ones. The continuous in-house R&D activities of occasional innovators reduce the incidence of only lack of market information. Cooperation within a firm or within a group of these innovators while developing product and process

innovation enhances this as well as the dominant position and cost obstacles (Annex, Table A3). Surprisingly, irregular in-house R&D activities do not reveal any innovation barriers, although the frequency of conducting them is three times larger than continuous R&D. They probably are too small to reveal any obstacles.

External sources of knowledge enhance the sensitivity to the perception of innovation obstacles more often for occasional innovators than persistent innovators. Differences in the frequency of the use of external sources of knowledge between two types of innovators accompany differences in the perception of innovation obstacles conditional on knowledge sources.

Firstly, the purchase of intangible technology seems to substitute the rare involvement of these innovators in in-house R&D activities. However, the purchase of intangible technology increases the sensitivity to perception of 5 obstacles of innovation: two financial ones, 'lack of market information', 'uncertain demand for innovative goods', and 'no demand for innovative goods'.

Secondly, occasional innovators focus on the development of process innovations. Their cooperation and subcontracting of innovative goods while developing process innovations strongly increases the incidence of four obstacles linked to the excessive costs of innovation, the dominant position of established firms in the innovative goods market and the lack of market and technology information. The increase in sensitivity to the perception of these four obstacles is very high. The coefficient is 2-3 times higher than in the case of persistent innovators (Annexes, Table A2 and A3). When occasional innovators introduce *process* innovation, the probability of perceiving obstacles to innovation always increases. However, when they develop *product* innovation, the sensitivity to the perception of two financial obstacles and 'no need to innovate due to lack of demand for innovative goods' is reduced. This suggests that process innovation, which is the focus of their innovation strategy, reveals the weaknesses of their innovation resources.

Thirdly, the use of market information on innovation reveals the sensitivity to the perception of more obstacles than cooperation while developing process innovation and cooperation in innovation activities. This was not the case for persistent innovators. The use of market information from competitors increased the sensitivity to the perception of 5 obstacles, i.e. more than in the case of cooperation while developing process innovation. However,

cooperation in the innovation activities of occasional innovators increases the sensitivity to the perception of economic obstacles and excessive costs of innovation. It also reduces the sensitivity to the perception of lack of market and technology information.

Finally, in all cases, sensitivities to the perception of innovation obstacles of occasional innovators was much stronger than in the case of persistent ones. This especially concerns the increase in sensitivity to the perception of 4 obstacles; the dominant position of an established firm in the innovative goods market, the excessive cost of innovation, the lack of market information and the lack of external finances.

In the case of occasional innovators we have also found disparities between the frequency of obstacles perceived by respondents (Table 2) and the frequency of perceiving obstacles conditional on knowledge sources, i.e., actual obstacles. In the case of at least 4 obstacles: lack of qualified personnel, lack of information on technology, difficulties in finding a cooperation partner, no need for innovation because of prior innovation, the CIS respondents overestimated the frequency of obstacles that their firms faced. 33.5% of occasional innovators cited 'difficulties in finding a cooperation partner' as an important or very important obstacle to innovation (Table 2), while 21.6% cited 'no need to innovate because of prior innovation'. However both obstacles were not revealed by any knowledge source that occasional innovators used. As much as 35.6% of occasional innovators noted the lack of qualified personnel as an important obstacle. However, the sensitivity to the perception of this obstacle increased only while firms used market information from competitors, i.e., as much as 8.2% of the total number of occasional innovators. 31.9% of occasional innovators cited the lack of information on technology as a significant obstacle to innovation. However, the sensitivity to the perception of this obstacle increased in firms that used 2 knowledge sources (cooperation while developing product innovation, market information from customers) i.e., 13% of occasional innovators. Firms also overestimated the frequency with which they face market dominated by an established firm and the excessive cost of innovation.

Comparing the perceived and actual obstacles to innovation of persistent and occasional innovators we find some similarities and differences. In both groups of innovators, continuous in-house R&D activities decrease the sensitivity to the perception of innovation barriers, while irregular R&D activities increase this sensitivity. Continuous R&D activities also reveal more innovation obstacles than irregular R&D activities.

The differences between the two groups of innovators in terms of knowledge sources they use have an impact on the differences in the sensitivity to the perception of various obstacles and the frequency of facing those obstacles. Often the same innovation obstacles are revealed in cooperation with different partners and the same innovation source reveals a sensitivity to the perception of different obstacles in persistent as compared to occasional innovators. The sensitivity to perception of actual obstacles lowers more frequently in persistent innovators than occasional innovators. The sensitivity to perception of actual obstacles increases more frequently in occasional than persistent innovators.

The excessive cost of innovation, the dominant position of an established firm, and the cost obstacle are most often cited by knowledge sources and the sensitivity to the perception of these barriers increases in both groups of innovators. However they are more often revealed by knowledge sources in occasional innovators than persistent innovators. The probability of perceiving difficulties in finding a cooperation partner lowers more frequently in the case of persistent innovators. No knowledge source reveals this as an obstacle in occasional innovators. On the other hand, the sensitivity to the perception of lack of market information increases frequently in occasional innovators and rarely in persistent ones

To sum up, both groups of innovators overestimate the frequency of two obstacles: skill and 'no need to innovate because of prior innovation'. The frequency of two financial obstacles and no need to innovate because of lack of demand is overestimated by persistent innovators. The lack of information on technology is overestimated by occasional innovators. The decrease in sensitivity to the perception of innovation obstacles takes place in occasional innovators quite rarely while an increase in this sensitivity occurs more often than in case of persistent innovators. In addition, the increase in sensitivity to the perception of all innovation obstacles is much stronger in the case of occasional innovators.

6. Impact of innovation obstacles on innovation activities

In the previous section we compared the frequency of obstacles that were perceived by managers (subjective) and the frequency of actual obstacles, which were conditional on a knowledge source. This section examines the impact of innovation obstacles on the

innovation activities of both persistent and occasional innovators. We will examine whether innovation obstacles prevent innovating firms from engaging in innovation activities, which results in the firms transitioning into non-innovating firms or whether innovation obstacles reveal weaknesses of innovation activities, namely knowledge resources of innovating firms. We ask which obstacles are strong enough to have an impact on the transfer of firms between the subgroup of innovators (in one of analysed periods) and non-innovators (in the previous / next period) and which obstacles are so weak that they do not impact the transfer of firms between the two subgroups.

In order to examine the effect of innovation obstacles on the transfer of firms between the two subgroups we use the biprobit model as reported in table 3 and 4. Two models: one considering the transfer of firms from non-innovating to innovating subgroups (Table 3) and the second considering the transfer of occasional firms from innovating to non-innovating subgroup (Table 4) are estimated. The independent variables are obstacles to innovation. The model shows obstacles that are so strong that they impact on the transfer of some occasional firms from innovating (in a given period) to non-innovating (in the next period) subgroup, meaning obstacles that "pushed" firms from an innovating to a non-innovating position. The model also shows which obstacles are too weak to cause this transfer.

Table 3. Results of biprobit model for occasional innovators that do not innovate in the first period and innovate in the second period and for persistent innovators

	Coef	Std. Err	P>|z|
Lack of funds within firm or group	-.00383	05884	0.948
Lack of finance from sources outside your firm	-.09964	.05819	0.087
Innovation costs too high	**.13976**	.05714	**0.014**
Lack of qualified personnel	.02606	.05602	0.642
Lack of information on technology	**-.15486**	.06650	**0.020**
Lack of information on markets	. 10433	.06987	0.135
Difficulties in finding cooperation partners	**-.20071**	.05713	**0.000**
Market dominated by established firms	-.00431	.05367	0.936
Uncertain demand for innovative goods	**.21468**	.05391	**0.000**
No need due to prior innovation	-.05754	.06489	0.375
No need because of no demand for innovations	**-.18978**	.06427	**0.003**
cons	.39516	.04222	0.000

	Coef	Std. Err	P>|z|
Occasional innovators			
Lack of funds within firm or group	-.06580	.06718	0.327
Lack of finance from sources outside your firm	-.05292	.06719	0.431
Innovation costs too high	.12353	06827	0.070
Lack of qualified personnel	.04299	06605	0.515
Lack of information on technology	.12088	.07796	0.121
Lack of information on markets	.08876	.08043	0.270
Difficulties in finding cooperation partners	.02280	.06783	0.737
Market dominated by established firms	.00456	.06363	0.943
Uncertain demand for innovative goods	**-.14040**	.06389	**0.028**
No need due to prior innovation	**-.21798**	.07780	**0.005**
No need because of no demand for innovations	.02491	07360	0.735
cons	-1.00213	04950	0.000

Log likelihood = -2985.5665 Correlations for disturbances are positive. Significance at 0.05 level. Significant obstacles are in bold.

Only two innovation obstacles (uncertain demand for innovative goods or services and no need to innovate due to prior innovation) are significant for occasional firms that do not innovate in the first period (Table 3). A drop in the impact of both obstacles (negative coefficients) accompanies the shift of occasional firms from non-innovating (in the first period) to innovating (in the next period) subgroup. This suggests that these two obstacles had a strong impact on the ability to innovate. As the strength of the impact diminishes, firms shift to the innovating subgroup

Five obstacles are significant for persistent innovators. The increase in the impact of two of them (excessive cost of innovation and uncertain demand for innovative goods) does not "push' occasional innovators out of the innovating sub-group into the non-innovating subgroup. The impact of both obstacles on the ability to innovate is rather weak. Although the impact of three obstacles (difficulties in finding a cooperation partner, lack of technological information and no need to innovate because of no demand for innovation product) has dropped, persistent innovators do not shift to the non-innovating subgroup. Irrespective of the drop or increase of impact of obstacles, persistent innovators continue their innovation activities. Obstacles to innovation do not prevent them from continuing innovation activities.

Table 4. Results of biprobit model for occasional firms that innovate in the first period and stop innovating in the second period and for persistent innovators

	Coef.	Std. Err.	P>|z|
Lack of funds within firm or group	-.00327	.05881	0.956
Lack of finance from sources outside firm	-.09546	.05818	0.101
Innovation costs too high	**.13773**	.05584	**0.014**
Lack of qualified personnel	.03027	.05587	0.588
Lack of information on technology	**-.14990**	.06540	**0.022**
Lack of information on market	.06754	.06861	0.325
Difficulties in finding cooperation partners	**-.19959**	.05671	**0.000**
Market dominated by established firms	-.00001	.05368	1.000
Uncertain demand for innovative goods	**.22738**	.05445	**0.000**
No need due to prior innovation	-.04828	.06566	0.462
No need because of no demand for innovations	**-.20053**	.06451	**0.002**
cons	.39188	.04253	0.000
Occasional innovators			
Lack of funds within firm or group	.05928	.06705	0.377
Lack of finance from sources outside your firm	**.14643**	.06687	**0.029**
Innovation costs too high	**-.25894**	.06338	**0.000**
Lack of qualified personnel	-.11972	.06498	0.065
Lack of information on technology	.12962	.07522	0.085
Lack of information on market	**-.15778**	.07875	**0.045**
Difficulties in finding cooperation partners	.25509	.06523	0.000
Market dominated by established firms	-.02126	.06197	0.732
Uncertain demand for innovative goods	**-.18108**	.06285	**0.004**
No need due to prior innovation	**.24828**	.07073	**0.000**
No need because of no demand for innovations	**.21599**	.07038	**0.002**
cons	-.89502	.04725	0.000

Log likelihood = -2988.3347. Significance at 0.05 level. Correlations for disturbances are positive.

Table 4 presents six innovation obstacles that are significant for occasional innovators that innovated in the first period but do not innovate in the second period. These are excessive costs of innovation, lack of finance from sources outside the firm, lack of information on market, no need to innovate due to prior innovation, no need to innovate because of no demand for innovations and uncertain demand for innovative goods. The impact of three

obstacles (lack of finance from sources outside the firm, no need to innovate due to prior innovation, no need to innovate because of no demand for innovations) increased. It was accompanied by a "push" which moved innovating firms from the innovating to non-innovating subgroup. This suggests that these three obstacles prevent occasional firms from innovating. The drop in impact of three other obstacles (excessive cost of innovation, uncertain demand for innovative goods and lack of market information) accompanies the shift of occasionally innovating firms to the non-innovating subgroup. This confirms that other obstacles 'push' firms out from the innovating to the non-innovating subgroups.

7. Summary and conclusions

Permanent and occasional innovators are quite similar in terms of firm size, ownership and technology intensity as well as in terms of frequency of perception of obstacles to innovation they recognise as significant. However, in terms of innovation activities, including their sources and strategies, they differ quite considerably.

We find a discrepancy between the frequency of innovators' (subjective) perception of obstacles and the frequency of facing actual obstacles, i.e. the ones that are conditional on knowledge sources. For example both groups of innovators overestimate frequency of facing two obstacles (lack of qualified personnel and no need to innovate due to prior innovation). Firms of the panel face these obstacles less frequently than they . In the case of persistent innovators, two financial obstacles and no need to innovate because of no demand for innovative goods is overestimated. In the case of occasional innovators the lack of information on technology is overestimated.

Differences in the frequency of the use of knowledge sources between the two groups of innovators are reflected in the difference in the frequency of facing obstacles. The less frequent use of knowledge sources of occasional innovators accompanies a more frequent increase in the sensitivity to the perception of actual obstacles and a less frequent drop in this sensitivity. The sources of knowledge used by persistent innovators enhance the sensitivity to the perception of actual obstacles less frequently and reduce this sensitivity

more frequently than in case of occasional innovators. When persistent innovators are better endowed in terms of knowledge sources, they face actual obstacles to innovation less frequently. In case of occasional innovators, the increase in the sensitivity to the perception of actual obstacles is not only more frequent but also stronger than in the case of persistent ones.

Differences in the endowment of knowledge sources between the two groups of innovators means that often the same obstacles revealed during cooperation of persistent innovators reflect the sensitivity to the perception of different actual obstacles than in the case of occasional innovators.

Internal sources of knowledge more frequently lower the sensitivity to the perception of obstacles in the case of persistent than occasional innovators. A shortage of internal sources of knowledge, especially low engagement in in-house R&D activities and a high dependence on external sources of knowledge of occasional innovators, has an impact on the increase in their sensitivity to the perception of innovation obstacles conditional on external knowledge sources.

Only 3 out of 11 innovation obstacles act as factors preventing occasional innovators from engaging in innovation activities and push them into the non-innovating subgroup. These are: lack of finance from sources outside a firm, no need to innovate due to prior innovation and no need to innovate due to no demand. Three other obstacles: excessive costs of innovation, uncertain demand for innovative goods and lack of market information do not prevent occasional innovators from engaging in innovation activities. The operation of these obstacles does not push occasional innovators into the non-innovating subgroup. Irrespective of the increase or the decrease of the impact of innovation obstacles on innovation activities, persistent innovators do not stop innovating. This suggests that the impact of obstacles is hampered or neutralised by knowledge resources that persistent innovators are endowed with. All of the considered obstacles to innovation reveal the weaknesses of innovation activities of persistent firms. Most (8 out of 11) obstacles to innovation of occasional innovators reveal weaknesses in knowledge resources that they use less frequently than their persistent counterparts. Our analysis supports the view that how firms innovate and how frequently and which knowledge resources they use is linked to the obstacles to innovation they face and their impact on innovation activities.

Appendix

A.1. Explanatory variables used in the analysis. Reference category is bolded

Group of variables	Variables	No. of variables in probit model
Firm size	**small**, medium, large	2
Technology intensity	**Low**, medium-low, medium-high, high technology	3
Exports of innovation products as % of sales	**no exporting**, exporting <10%, exporting >10%	2
R&D activity	**no R&D activity**, continuous R&D activity, R&D on occasion	2
Ownership	**domestic**, foreign	1
Purchase of other technology	**no purchase**, purchase	1
Development of new product	**not introduced a new product**, developed within firm and group, developed in cooperation, domestic institutions, foreign institutions	4
Development of new process	**not introduced a new process**, developed within firm or its group, developed in cooperation, domestic institutions, foreign institutions	4
Cooperation in innovation activities	**within firm or its group**, suppliers, customers, competitors, R&D institutions	4
Sources of market information	**within firm or its group**, suppliers, customers, competitors, R&D institutions, other	5
TOTAL		28

A2. Probit model of obstacles to innovation.

	Fin.int		Fin.ext		Cost		Skills		Tech.inf		Mark.inf		Coop		Monopol		Unce.dem		No dem		No need	
Large	**-0.563**	(0.000)	**-0.423**	(0.000)	**-0.536**	(0.000)	**-0.365**	(0.000)	-0.138	(0.181)	-0.043	(0.682)	**-0.307**	(0.003)	**-0.341**	(0.001)	**-0.518**	(0.000)	-0.185	(0.093)	0.053	(0.628)
Medium	**-0.312**	(0.001)	**-0.221**	(0.010)	**-0.258**	(0.005)	**-0.193**	(0.021)	-0.111	(0.201)	-0.002	(0.981)	**-0.279**	(0.001)	**-0.245**	(0.003)	**-0.404**	(0.000)	**-0.229**	(0.014)	0.043	(0.646)
HT	*0.131*	(0.357)	-0.039	(0.779)	0.133	(0.368)	**0.309**	(0.028)	0.244	(0.091)	**0.296**	(0.041)	0.226	(0.124)	0.141	(0.310)	-0.211	(0.131)	-0.027	(0.866)	**0.305**	(0.041)
MHT	0.001	(0.994)	0.024	(0.732)	0.103	(0.160)	**0.249**	(0.001)	0.099	(0.184)	**0.156**	(0.040)	**0.199**	(0.008)	0.016	(0.815)	**-0.168**	(0.017)	**-0.212**	(0.010)	0.034	(0.667)
MLT	-0.125	(0.067)	**-0.193**	(0.004)	-0.037	(0.600)	0.057	(0.412)	0.033	(0.643)	0.004	(0.959)	**0.171**	(0.017)	**-0.210**	(0.002)	**-0.400**	(0.000)	-0.119	(0.128)	-0.049	(0.525)
R&D contin.	**-0.223**	(0.011)	**-0.313**	(0.000)	-0.083	(0.366)	-0.144	(0.118)	-0.084	(0.384)	0.009	(0.922)	**-0.247**	(0.011)	0.069	(0.437)	0.142	(0.110)	**-0.211**	(0.050)	-0.179	(0.084)
R&D occasion	0.033	(0.619)	-0.065	(0.318)	-0.037	(0.587)	**0.130**	(0.050)	**0.219**	(0.001)	**0.181**	(0.009)	-0.067	(0.329)	0.061	(0.349)	-0.001	(0.985)	0.050	(0.499)	0.035	(0.634)
Foreign group	**-0.512**	(0.000)	**-0.490**	(0.000)	**-0.301**	(0.000)	**-0.208**	(0.004)	**-0.172**	(0.022)	**-0.282**	(0.000)	**-0.367**	(0.000)	**-0.252**	(0.000)	**-0.268**	(0.000)	-0.117	(0.149)	**-0.235**	(0.003)
Exp 0-10%	-0.062	(0.403)	0.038	(0.602)	-0.057	(0.453)	-0.078	(0.298)	0.049	(0.525)	-0.084	(0.286)	0.078	(0.312)	-0.081	(0.265)	**-0.180**	(0.014)	0.036	(0.670)	-0.075	(0.360)
Exp >10%	-0.002	(0.984)	0.067	(0.413)	**-0.207**	(0.015)	**0.162**	(0.049)	-0.098	(0.262)	-0.163	(0.067)	-0.044	(0.619)	**-0.221**	(0.007)	**-0.397**	(0.000)	0.077	(0.415)	**-0.214**	(0.024)
Extern. techno.	-0.015	(0.826)	-0.003	(0.970)	0.044	(0.541)	0.051	(0.470)	-0.125	(0.091)	-0.090	(0.233)	0.058	(0.423)	0.049	(0.475)	0.093	(0.182)	-0.048	(0.544)	0.024	(0.752)
PT.within firm	0.157	(0.055)	0.134	(0.099)	-0.003	(0.974)	-0.030	(0.715)	0.030	(0.730)	0.050	(0.569)	-0.145	(0.087)	**0.174**	(0.031)	**0.290**	(0.000)	-0.069	(0.458)	-0.082	(0.353)
Proces.within	0.012	(0.909)	-0.136	(0.182)	-0.061	(0.571)	0.101	(0.328)	0.075	(0.482)	-0.145	(0.172)	-0.029	(0.782)	-0.120	(0.236)	-0.074	(0.464)	**-0.249**	(0.028)	-0.088	(0.424)
PT.in coop.	0.117	(0.297)	0.082	(0.461)	**0.267**	(0.025)	0.101	(0.374)	0.047	(0.694)	-0.017	(0.892)	-0.065	(0.576)	**0.235**	(0.035)	**0.350**	(0.002)	-0.101	(0.438)	-0.178	(0.160)
Proces. in coop.	0.050	(0.669)	-0.073	(0.531)	-0.104	(0.395)	0.116	(0.331)	-0.051	(0.679)	-0.194	(0.116)	-0.040	(0.745)	-0.108	(0.354)	-0.060	(0.610)	-0.247	(0.060)	-0.212	(0.101)
PT sub.dom	-0.368	(0.170)	-0.318	(0.239)	**0.626**	(0.050)	-0.337	(0.248)	-0.324	(0.317)	-0.700	(0.068)	**-0.876**	(0.011)	-0.270	(0.335)	-0.179	(0.516)	0.154	(0.600)	-0.217	(0.471)
Proces.sub.dom	-0.134	(0.347)	0.012	(0.931)	-0.055	(0.715)	-0.015	(0.921)	-0.250	(0.110)	**-0.490**	(0.002)	-0.209	(0.171)	-0.163	(0.254)	-0.219	(0.126)	**-0.400**	(0.015)	-0.154	(0.325)
PT sub.foreign	-0.548	(0.074)	-0.466	(0.122)	**-0.737**	(0.013)	-0.478	(0.126)	-0.297	(0.407)	-0.289	(0.419)	**-0.842**	(0.036)	-0.127	(0.684)	-0.393	(0.223)	-0.260	(0.467)	-0.244	(0.496)
Proces.sub.foreign	0.089	(0.625)	0.085	(0.641)	-0.027	(0.887)	**0.380**	(0.039)	-0.133	(0.510)	-0.077	(0.700)	-0.059	(0.763)	-0.287	(0.129)	-0.016	(0.930)	-0.146	(0.477)	-0.089	(0.662)
Coop.inn.supp.	-0.091	(0.195)	-0.041	(0.557)	0.076	(0.290)	-0.053	(0.457)	**0.159**	(0.030)	0.027	(0.722)	**0.170**	(0.019)	-0.104	(0.138)	-0.125	(0.074)	-0.027	(0.738)	-0.075	(0.335)
Coop.inn.custom	0.014	(0.867)	0.070	(0.385)	-0.013	(0.873)	**0.231**	(0.005)	-0.086	(0.314)	0.132	(0.127)	0.007	(0.931)	**0.169**	(0.035)	0.100	(0.214)	-0.027	(0.774)	0.067	(0.467)
Coop.inn.compet	0.010	(0.916)	**0.193**	(0.046)	0.052	(0.608)	-0.042	(0.666)	-0.083	(0.423)	-0.083	(0.427)	-0.088	(0.389)	0.157	(0.103)	0.158	(0.105)	0.041	(0.718)	-0.174	(0.127)
Coop.inn.R&D	0.120	(0.113)	0.014	(0.854)	0.149	(0.056)	-0.053	(0.490)	**-0.160**	(0.047)	-0.031	(0.706)	0.110	(0.162)	**0.198**	(0.008)	**0.200**	(0.008)	**0.211**	(0.015)	-0.016	(0.848)
Info. suppliers	0.081	(0.290)	-0.004	(0.959)	0.019	(0.816)	0.003	(0.973)	-0.135	(0.103)	0.012	(0.886)	-0.023	(0.781)	**-0.172**	(0.027)	**-0.256**	(0.001)	0.054	(0.538)	-0.007	(0.938)
Info.custom	-0.088	(0.179)	0.005	(0.945)	**0.181**	(0.008)	-0.030	(0.656)	-0.036	(0.603)	-0.121	(0.086)	-0.125	(0.073)	0.004	(0.957)	0.033	(0.617)	**-0.187**	(0.015)	0.056	(0.442)
Info.compet.	0.126	(0.111)	0.019	(0.809)	**0.240**	(0.004)	0.099	(0.211)	0.054	(0.511)	0.051	(0.544)	-0.123	(0.141)	**0.288**	(0.000)	**0.264**	(0.001)	0.152	(0.087)	0.009	(0.920)
Info.R&D	-0.167	(0.072)	**-0.206**	(0.025)	**-0.284**	(0.003)	0.021	(0.826)	0.100	(0.300)	0.154	(0.116)	0.012	(0.902)	0.007	(0.937)	0.046	(0.619)	0.135	(0.186)	**0.272**	(0.006)
Info.other	**0.158**	(0.016)	**0.309**	(0.000)	**0.254**	(0.000)	0.098	(0.133)	**0.190**	(0.005)	0.057	(0.413)	**0.157**	(0.020)	**0.161**	(0.013)	0.065	(0.319)	-0.066	(0.383)	-0.091	(0.213)
Cons	**0.611**	(0.000)	**0.389**	(0.006)	**0.699**	(0.000)	**-0.442**	(0.002)	**-0.623**	(0.000)	**-0.574**	(0.000)	**-0.273**	(0.062)	0.036	(0.797)	**0.501**	(0.000)	**-0.355**	(0.023)	**-0.564**	(0.000)

Table A3. Probit model of obstacles to innovation. Occasional innovators

	Fin.int		Fin.ext		Costs		Skills		Tech.inf		Mark.inf		Coop		Monopol		Unce.dem		No dem		No need	
Large	**-0,310**	(0,028)	**-0,554**	(0,000)	**-0,733**	(0,000)	**-0,445**	(0,002)	**-0,442**	(0,003)	-0,215	(0,165)	**-0,313**	(0,032)	-0,263	(0,062)	-0,201	(0,149)	0,140	(0,376)	0,077	(0,609)
Medium	**-0,202**	(0,029)	**-0,600**	(0,000)	**-0,632**	(0,000)	-0,174	(0,055)	**-0,219**	(0,017)	-0,163	(0,089)	**-0,347**	(0,000)	**-0,285**	(0,002)	-0,155	(0,084)	0,168	(0,101)	-0,002	(0,986)
HT	-0,062	(0,740)	-0,233	(0,218)	**-0,662**	(0,001)	0,212	(0,252)	-0,010	(0,959)	0,296	(0,125)	-0,069	(0,718)	0,263	(0,164)	0,005	(0,978)	**0,574**	(0,003)	0,226	(0,244)
MHT	0,174	(0,103)	-0,037	(0,729)	-0,133	(0,223)	-0,009	(0,933)	-0,021	(0,850)	0,047	(0,678)	**0,221**	(0,041)	0,056	(0,595)	0,054	(0,610)	0,121	(0,295)	-0,014	(0,900)
MLT	0,051	(0,583)	**-0,157**	(0,091)	**-0,222**	(0,019)	-0,037	(0,691)	-0,019	(0,847)	-0,026	(0,797)	-0,038	(0,689)	-0,066	(0,478)	-0,026	(0,774)	-0,161	(0,127)	**-0,314**	(0,002)
R&D contin.	-0,303	(0,147)	-0,291	(0,165)	0,116	(0,588)	-0,223	(0,317)	-0,319	(0,165)	**-0,861**	(0,003)	0,199	(0,347)	-0,080	(0,710)	0,300	(0,156)	-0,004	(0,986)	-0,150	(0,517)
R&D occasion	-0,089	(0,446)	-0,144	(0,218)	0,170	(0,168)	0,145	(0,213)	0,162	(0,170)	-0,037	(0,764)	0,156	(0,188)	-0,150	(0,204)	-0,122	(0,292)	0,067	(0,611)	0,035	(0,782)
Foreign group	**-0,658**	(0,000)	**-0,530**	(0,000)	**-0,336**	(0,001)	-0,175	(0,102)	**-0,323**	(0,004)	**-0,472**	(0,000)	**-0,422**	(0,000)	**-0,400**	(0,000)	**-0,343**	(0,001)	-0,090	(0,437)	-0,127	(0,261)
Exp. 0-10%	0,122	(0,625)	0,159	(0,519)	0,058	(0,817)	-0,333	(0,183)	-0,272	(0,281)	-0,092	(0,720)	0,331	(0,186)	-0,264	(0,275)	0,483	(0,049)	-0,074	(0,798)	-0,542	(0,074)
Exp. >10%	-0,080	(0,769)	0,096	(0,723)	-0,289	(0,290)	-0,059	(0,825)	0,213	(0,422)	0,123	(0,663)	0,203	(0,466)	**-1,246**	(0,001)	-0,386	(0,156)	-0,235	(0,489)	-0,395	(0,211)
Extern.techno.	**0,287**	(0,003)	**0,196**	(0,040)	0,134	(0,171)	0,007	(0,943)	0,192	(0,054)	**0,254**	(0,017)	0,457	(0,000)	0,201	(0,037)	**0,450**	(0,000)	0,152	(0,157)	**0,242**	(0,020)
PT. within	-0,394	(0,182)	-0,032	(0,912)	0,609	(0,070)	-0,157	(0,590)	0,328	(0,254)	**0,859**	(0,003)	-0,139	(0,655)	0,866	(0,004)	0,175	(0,529)	-0,284	(0,479)	-0,093	(0,786)
Proc.within	-0,489	(0,102)	-0,191	(0,515)	**0,736**	(0,030)	-0,186	(0,526)	0,206	(0,479)	**0,864**	(0,003)	-0,014	(0,964)	0,842	(0,005)	0,139	(0,620)	-0,204	(0,614)	-0,310	(0,370)
PT.in coop	**-0,797**	(0,025)	-0,173	(0,624)	0,527	(0,187)	0,226	(0,525)	-0,198	(0,589)	0,654	(0,077)	-0,662	(0,077)	0,315	(0,392)	-0,513	(0,138)	-0,631	(0,199)	**-0,985**	(0,030)
Proc.in coop	-0,325	(0,308)	-0,002	(0,994)	0,570	(0,109)	0,129	(0,681)	**0,610**	(0,050)	**0,891**	(0,005)	0,223	(0,502)	**0,867**	(0,007)	0,050	(0,866)	-0,013	(0,976)	-0,102	(0,779)
PT.sub.dom	0,433	(0,369)	0,886	(0,080)	**1,878**	(0,003)	-0,315	(0,472)	-0,329	(0,501)	0,336	(0,476)	0,349	(0,400)	**2,097**	(0,000)	0,237	(0,553)	-0,450	(0,432)	-0,920	(0,111)
Proc. sub.dom	-0,209	(0,504)	-0,035	(0,909)	0,647	(0,071)	-0,089	(0,771)	0,178	(0,560)	**1,022**	(0,001)	-0,015	(0,964)	**0,807**	(0,012)	0,207	(0,480)	-0,281	(0,503)	-0,458	(0,210)
PT. sub.foreign	(omitted)		**-1,410**	(0,020)	0,065	(0,911)	-0,119	(0,817)	0,237	(0,639)	1,095	(0,025)	-0,867	(0,169)	0,143	(0,792)	-0,202	(0,689)	-0,621	(0,371)	0,643	(0,231)
Proc.sub.foreign	0,033	(0,932)	0,356	(0,341)	**1,046**	(0,012)	0,032	(0,930)	0,606	(0,102)	1,344	(0,000)	0,315	(0,416)	**1,407**	(0,000)	0,644	(0,074)	0,392	(0,403)	0,097	(0,816)
Coop.inn.supp	0,274	(0,143)	**0,460**	(0,013)	-0,134	(0,467)	-0,245	(0,192)	**-0,425**	(0,032)	**-0,474**	(0,027)	-0,003	(0,989)	-0,371	(0,052)	-0,056	(0,754)	-0,281	(0,216)	0,120	(0,543)
Coop.inn.custom	0,259	(0,287)	-0,144	(0,544)	**0,645**	(0,013)	-0,082	(0,728)	-0,098	(0,687)	0,323	(0,197)	0,190	(0,422)	0,351	(0,146)	**0,592**	(0,013)	0,049	(0,864)	0,374	(0,148)
Coop.inn.compet	-0,584	(0,071)	-0,613	(0,059)	-0,506	(0,120)	0,331	(0,292)	0,518	(0,108)	0,625	(0,058)	-0,001	(0,996)	0,246	(0,431)	-0,226	(0,471)	0,489	(0,188)	-0,526	(0,158)
Coop.inn.R&D	0,360	(0,107)	0,103	(0,640)	0,029	(0,897)	-0,235	(0,297)	0,251	(0,269)	-0,031	(0,901)	0,159	(0,480)	0,279	(0,217)	0,394	(0,074)	-0,362	(0,189)	-0,313	(0,226)
Info.suppliers	0,019	(0,912)	-0,130	(0,430)	0,151	(0,389)	0,046	(0,778)	0,114	(0,501)	-0,057	(0,746)	0,320	(0,059)	-0,029	(0,861)	-0,110	(0,502)	-0,180	(0,376)	-0,337	(0,079)
Info.custom	0,195	(0,211)	0,269	(0,079)	0,284	(0,080)	-0,006	(0,969)	**0,325**	(0,034)	0,299	(0,060)	-0,300	(0,075)	0,158	(0,306)	0,089	(0,562)	-0,328	(0,092)	-0,072	(0,678)
Info.compet	0,218	(0,233)	0,208	(0,244)	**0,389**	(0,050)	**0,427**	(0,015)	0,127	(0,476)	**0,376**	(0,037)	0,238	(0,193)	**0,378**	(0,035)	**0,557**	(0,002)	-0,221	(0,329)	0,059	(0,770)
Info.R&D	-0,377	(0,051)	-0,163	(0,395)	-0,356	(0,071)	0,068	(0,720)	0,147	(0,440)	0,307	(0,120)	0,269	(0,161)	-0,348	(0,081)	-0,093	(0,628)	0,213	(0,330)	0,203	(0,333)
Info.other	0,066	(0,638)	-0,100	(0,476)	0,143	(0,333)	0,151	(0,274)	0,170	(0,228)	0,054	(0,715)	0,187	(0,194)	0,202	(0,145)	0,130	(0,351)	-0,055	(0,741)	-0,227	(0,157)
Cons	**0,655**	(0,044)	**0,641**	(0,044)	0,169	(0,643)	-0,105	(0,742)	**-0,720**	(0,024)	**-1,571**	(0,000)	-0,527	(0,123)	**-0,938**	(0,004)	-0,434	(0,158)	-0,739	(0,088)	-0,426	(0,250)

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