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Determinants of business innovation in the Regional Innovation System context. Policy implications for a less developed region

Abstract: The purpose of this study is to identify the determinants of innovation of enterprises in the Regional Innovation System context. We analyse factors that determine regional innovation in a less developed region, taking the Podkarpackie region in Poland as our empirical counterpart. We examine how the EU economic policy instruments influence the innovation of enterprises within the context of the Regional Innovation Systems. We propose a model for the implementation of innovations and test our hypotheses based on the data drawn from the period of 2011–2014. The paper provides insights on a rather successful story from Poland. We posit that enterprises use only specific public policy instruments and that companies' demand for innovation-supporting instruments changes, reacting to the business cycle phase and to financial incentives.

Keywords: Regional Innovation System, innovation drivers, entrepreneurship, innovation policy effects, regional development, NUTS-2

Uwarunkowania innowacyjności przedsiębiorstw w kontekście regionalnego systemu innowacji. Implikacje polityczne dla regionów słabiej rozwiniętych

Abstrakt: Celem tego badania jest identyfikacja uwarunkowań innowacyjności przedsiębiorstw w kontekście regionalnego systemu innowacji. Analizujemy czynniki determinujące regionalne innowacje w słabiej rozwiniętym regionie na przykładzie Podkarpacia. Badamy, w jaki sposób instrumenty polityki gospodarczej UE wpływają na innowacyjność przedsiębiorstw w kontekście Regionalnego Systemu Innowacji. Proponujemy model wdrażania innowacji i testujemy nasze hipotezy na podstawie danych z okresu 2011–2014. Zakładamy, że przedsiębiorstwa wykorzystują tylko konkretne instrumenty polityki publicznej i że zapotrzebowanie firm na instrumenty wspierające innowacje zmienia się w zależności od fazy cyklu koniunkturalnego i w reakcji na zachęty finansowe.

Słowa kluczowe: regionalny system innowacji, kierunki innowacji, przedsiębiorczość, efekty polityki innowacyjnej, rozwój regionalny, NUTS-2

1. Introduction

Innovation and competitiveness of countries and regions have acquired a special strategic importance. Poland is one of the least innovative countries in the European Union. In line with the EU strategy, the prospects for further development depend on the ability to raise the level of innovation by institutional incentives in all the Member States. In consequence, the responsibility for creating the conditions for innovation-driven growth has fallen upon the Regional Authorities – they responded by forming Regional Innovation Strategies. A Regional Innovation Strategy, based on the diagnosis of the region's innovation potential, defines the strategic objectives of the innovation policy. It indicates a sequence of actions and tasks necessary to boost the region's innovative development. A Regional Innovation Strategy aims to build an effective system of supporting innovation in the region. It is a tool for supporting regional and local authorities in stimulating the region's innovation capacity, and is addressed to all participants of the regional innovation system, i.e.: science, R&D, industry, the education system, finance, organisations bringing together entrepreneurs and business-related institutions and regional authorities. Regional innovation strategies are, consequently, the basis for building efficient regional innovation systems. A Regional Innovation System is a system of entities, interactions and events that, as a result of synergy, are created in a specific territory and increase the ability to create, absorb and diffuse innovations in the region. Regional Innovation Systems have provided for the implementation of many activities financed from the European Funds (within both financial perspectives 2007–2013 and 2014–2020).

The level of innovation is region-specific (Pater and Lewandowska, 2015; Buerger et al., 2012). On one hand, it is related to the availability and number of local institutional incentives as well as limitations in the geographical penetration of knowledge (Greunz, 2003). On the other hand, the differences result from the different "quality" or "efficiency" of Regional Innovation Systems. The level of innovative output is different even if the inputs are identical (Bai, 2013; Fritsch and Slavtchev, 2011). Therefore, from the policy perspective, the crucial efforts focus on the creation of an adequate business climate that promotes spontaneous innovation. Since knowledge-based economy is subjected to constant structural changes induced by technology, governments should provide a quick institutional response. This means constant monitoring and adjusting of the existing strategies for business on the regional level.

Most of the studies on regional innovation systems in general refer to ideal types or typologies of the institutional nexus or barriers to innovative growth. So far, there have been very few attempts to deal with the development of the institutionally-driven Regional Innovation Systems. It is therefore not shocking that the pioneering research in that field conducted by Doloreux and Dionne (2008) concludes that further research would fill the gaps in knowledge about the effectiveness of Regional Innovation Systems. Our research addresses that suggestion and provides empirical findings on whether this system improves the innovativeness of firms in the Podkarpackie region in Poland.

The Podkarpackie region, where the research was carried out, was not long ago considered to be dormant and underdeveloped. Some recent studies, however, provide evidence that innovative companies have emerged in this region (Lewandowska and Stopa, 2013). These successful cases occurred in the period of the application of EU economic policy instruments. The aim of this article is to explain which of the elements within the Regional Innovation System have induced innovation. It helps explain what drives innovation in a Cohesion region. The EU Cohesion strategy is similar in all the new Member States. That is why we think that our study brings universal conclusions as to the efficiency of innovation policy in an underdeveloped region.

The article is organised as follows. In the next section, we provide a literature review on institutional factors related to innovativeness – with a special focus on EU policy incentives. We also provide a brief description of the Podkarpackie region. In the third section, we present the survey data and describe the methodology. Section four presents and discusses the results. The paper ends with some concluding remarks.

2. Literature review

According to the Oslo Manual (2005:8), innovation is described by: "(…) changes which involve a significant degree of novelty for the firm".

Innovations are made within a specified area, with a system of linkages called an *innovation system.* It contains production sector (industry) and scientific subsystems, institutional solutions and interdependent relationships among these sub-systems. They are characterised by the level of innovativeness of the region (Grosse, 2007; Markowski, 2004).

Our research was conducted on the firm level. To our knowledge, there are a few studies (cf. e.g. Vaz et al., 2014; Sivak et al., 2011; Doloreux and Dionne, 2008; Bhaskaran, 2006; Bhattacharya and Bloch, 2004) on the attributes of innovation that are similar to ours. Among the attributes of innovation, they indicate that the promotion of knowledge and are correlated with innovativeness. Innovation is also related to managing and promoting R&D, as well as orientation towards innovativeness and cooperation between the participants of the innovation system. They also tested the attributes related to new product development and application of external technologies, but that group of attributes did not turn out to be significant. Their research was not conducted in a transforming economy, therefore we expected different results. Because of that, the best research to compare the results should come from studies carried out in Poland. Research by Baczko (2006) and Niedzielski and Jaźwiński (2002) has been very useful and provided some insights into innovativeness in Poland. Baczko (2006) described the results of foresight studies on the regional level that included clustering and the scale of regional long-term development challenges. In the study, however, the analysis did not include the companies' perspective.

There are several studies based on the results of the Community innovation survey (Wyszkowska-Kuna, 2015; Fagerberg et al., 2012; Kampik and Dachs,

2011; Harris and Li, 2011; Battisti and Stoneman, 2010). However, they focus mainly on the characteristics of innovation. Battisti and Stoneman (2010) explore the diffusion of a range of innovative activities. Our approach is broader and covers many aspects of the potential impact of instruments within the Regional Innovation System on innovation. Another advantage of our analysis is the inclusion of micro-firms which are not covered in official innovation surveys (e.g. the Community Innovation Survey – CIS) by the national statistical offices. Another strength of our research is that we consider the possible effects of a Regional Innovation System in more detail than the CIS does.

Doloreux and Dionne (2008) showed that a high level of concentrated and specialised knowledge infrastructure, efficient technology transfer and strong human capital appear to be the key factors leading to innovative actions. Essentially, they suggested that innovative potential of firms could be exploited more efficiently if institution-driven Regional Innovation System incentives aim at the promotion of individual competencies in public organisations. Additionally, they also suggested that innovation is related to *systems of relations* between organisations and social actors. This work was not an outlier in indicating that cooperation between various institutions could have a positive impact on innovativeness. For instance, Kaiser (2002) posits that good cooperation between business and research institutes allows for successful transfer of technological knowledge. However, we believe that successful implementation of basic research is only possible if the institutional system allows it, via a triple helix (Etzkowitz and Leydesdorff 1998) between the research community, government and industries.

Some authors look at the value-added network in terms of access to complementary resources (such as knowledge, information and finance). They researched the impact of joint projects, risk sharing and synergic effects of resource sharing (e.g. Smith and Waters, 2011). Huggins and Tompson (2015) suggested that entrepreneurial firms with a greater capacity to accumulate network capital achieve higher rates of innovation. An additional circumstance which creates and determines innovativeness is related to the benefits of clustering for innovative companies. Clustering supports companies looking for new technological possibilities. As the next step, there are limits to which knowledge can be effectively transferred and used (Lam, 1997). Finally, the transfer of knowledge in networks and clusters encourages imitation and can diminish returns from innovation.

We formulated the following hypothesis:

H1. Institutional support created by a Regional Innovation System induces firm-level innovation.

H2. The effectiveness of Regional Innovation System policy instruments for enterprises changes with the business cycle. During economic expansions companies increase innovation, while during economic contractions they decrease innovation. Weakly developed regions lack resources to be able to increase innovation during recessions in a Schumpeterian way.

H3. Enterprises from a less developed region change their preferences in the application of particular policy instruments as the innovation strategy unfolds in the following way:

a) in the initial period, they need consulting companies as they do not have practical knowledge on how to create innovations,
b) in the initial period, mostly companies with existing R&D departments introduce innovations; thus, other companies need guidance on how to cooperate in innovative activity; in the following years, lack of an R&D department is not a problem as it can be substituted by cooperation.

The Regional Innovation System mentioned in the hypotheses was created as a product of the decentralisation of the decision-making structures – from the EU to the national and then to the regional level. The aim of the Regional Innovation System is to enforce regional policymaking and accelerate innovation process in enterprises and other organisations. It defines and implements the institutional framework to stimulate innovation in the region (Asheim et al., 2011). In other words, it consists of the knowledge-diffusion-system and institutional infrastructure supporting innovation. The Regional Innovation System approach coordinates the "triggers" of innovation and intensifies the traffic within the created network between companies and organisations alike (Asheim and Gertler, 2005).

The Regional Innovation Strategy in the Podkarpackie region functioned in 2005–2013 as a policy tool used by local policymakers to create knowledge-based growth in the region. Regional Innovation Strategy funds were launched to facilitate the transfer of knowledge – one of the key points identified during the assessment. The Regional Innovation Strategy sets up the institutionally-driven Regional Innovation System.

Why was the Regional Innovation System important from the policy perspective? Podkarpackie is among the least developed regions in Poland in terms of GDP per capita, labour productivity, wages and infrastructure. The Podkarpackie Voivodship is ranked 15th in Poland (of 16 regions) in terms of GDP per capita. In 1997–2013, GDP per capita grew more slowly here than the Polish average. In consequence, the distance between Podkarpackie and the other regions of Poland has increased. The share of industry in the Gross Value Added (GVA) is estimated at 28.3%, which is the eighth highest result – above the national average (25.6%). However, services are poorly developed. The region is characterised by a high share of unprofitable and fragmented agriculture.

Podkarpackie's efficiency-driven manufacturing industry was considered to be dormant; however, in terms of innovation, it ranked quite high – 68th in the Regional Innovation Scoreboard (2014) which surveyed 190 European regions. When it comes to innovativeness, Podkarpackie was evaluated as a Moderate Innovator. According to the classification of the Regional Innovation Scoreboard 2016, Podkarpackie's Innovation performance has increased (+3%) over 2014–2016. The relative strengths of the regional innovation system include: Exports of medium and high-tech products, Tertiary education attainment and Non-R&D innovation expenditure. Relative weaknesses are in SMEs with marketing or organisational innovations, Public R&D expenditure and EPO patent applications. Was the Regional Innovation System responsible for this unprecedented innovation-driven shift of this local economy?

3. The data

We base our analysis on a questionnaire from the monitoring and evaluation of the regional innovation strategy in the Podkarpackie region. The sample selection for the survey was carried out by a stratified sampling method according to the size of the enterprise (number of employees) and its sector (NACE rev. 2 section, cf: Eurostat, 2008). The sampling criteria were rendered according to GDP contribution. The data were collected every year from 2011 to 2014. We used the Computer Assisted Telephone Interview (CATI) method. Approximately 400 companies were included each year (399 in 2011, 400 in 2012, 401 in 2013 and 401 in 2014). Due to certain problems in keeping a panel of the same enterprises, every year the sample was drawn anew from the population of regional firms. This resulted in having random samples within each stratum every year. A low share of the same enterprises surveyed every year prevented us from using a panel data model. The F test showed statistically insignificant differences between the panel group means (enterprise dummies) in such a highly unbalanced panel. It means that a pooled model could have been applied. That is why we analysed the data for each year separately, and afterwards we proceeded with the pooled data.

Table 1 shows groups of questions included in the questionnaire. Most of the questions were multiple-choice. Besides demographics, the questionnaire included information on the characteristics of innovation, determinants of innovation, its barriers and factors driving the effectiveness of innovation. In the modelling procedure, we tested the influence of different factors on the propensity of companies for innovation.

During 2011–2014, on average 29.8% of the companies declared that they had implemented innovations (Table 2). Half of them had implemented product innovations. On average, 15.25 of companies introduced product innovations. Next came process innovations, organisational innovations and marketing innovations In 2011–2014 innovations varied in terms of type were implemented. For instance, in 2011 there were more companies that introduced process than product innovations, whereas in 2012 and during the following years, product innovators prevailed.

Information gathered from the surveys indicated that companies "assimilate innovations" to stay ahead of the competition. For instance, most of the companies implemented product innovations defined as the acquisition of advanced equipment. Moreover, most of them implemented innovations that was new to the company. There were also companies that implemented innovations that were new to the world (Table 3). In other words, most of them changed the production lines during the last 12 months to perform better in the local and sometimes the global market.

Table 1. CATI survey questions

Symbol	Group of questions	Possible no. of answers
Age	age of the company	
Sector	sector of ownership (public / private)	
Size	size of the company	
Situation	self-assessed economic situation	
Dynamics	self-assessed dynamics of growth	
Innovation	implementation of innovations during last 12 months	2
innovation type	type of applied innovation	4
Scale	scale of innovation	4
Motive	motives for implementing innovation	8
internal barrier	internal factors hindering innovation	11
external barrier	external factors hindering innovation	8
Plans	plans to implement innovation during next 12 months	2
Information	sources of information about innovation	6
financing own	share (in %) of financing innovation from own resources	5
Financing	external means of financing innovation	9
Cooperation	other organisations the company was cooperating with during innovative activities	9
cooperation barrier	barriers of cooperation with business environment	7
cooperation factor	factors that help in initiating and developing cooperation	5
public support	public support for innovation	2
public type	type of investment made by the use of public funds	6
public constraints	constraints in raising funds from the EU	7
Cluster	participation in a cluster	2
cluster impact	impact of cluster participation on innovativeness	6
know institutions	knowledge about institutions supporting innovativeness	12
know consult	knowledge on consulting opportunities about innovation	4
know financing	knowledge on methods of financing innovation	6
know information	knowledge and use of information about support for innovation	5
know training	knowledge and use of training supporting innovation	4
know organisation	knowledge and use of organisational support instruments for innovative activities	5

Table 2. Innovation by type in 2011–2014 (% of total)

	2011		2012		2013		2014		2011–2014	
Innovative companies	123	(30.8%)	115	(28.8%)	122	(30.4%)	136	(29.2%)	496	(29.8%
Product innovation	46	(11.5%)	68	(17.0%)	66	(16.5%)	63	(15.7%)	243	(15.2%)
Process innovation	61	(15.3%)	58	(14.5%)	42	(10.5%)	49	(12.2%)	210	(13.1%)
Organisational innovation	27	(6.8%)	40	(10.0%)	53	(13.2%)	62	(15.5%)	182	(11.4%)
Marketing innovation	24	(6.0%)	27	(6.8%)	21	(5.2%)	28	(7.0%)	100	(6.2%)

Number (share) of companies that declared implementing innovations during the last 12 months.

Source: CATI survey.

Table 3. Innovation by level in 2011–2014 (% of total)

	2011		2012		2013		2014		2011–2014	
Innovative companies	123	(30.8%)	115	(28.8%)	122	(30.4%)	136	(29.2%)	496	(29.8%)
New to the company	96	(24.1%)	120	(30.0%)	129	(32.2%)	134	(33.4%)	479	(29.9%)
New in the industry	22	(5.5%)	20	(5.0%)	22	(5.5%)	59	(14.7%)	123	(7.7%)
New to the country	22	(5.5%)	8	(2.0%)	22	(5.5%)	3	(0.7%)	55	(3.4%)
New to the world	4	(1.0%)	4	(1.0%)	5	(1.2%)	1	(0.2%)	14	(0.9%)

Number (share) of companies that declared implementation of innovations during the last 12 months.

Source: CATI survey.

In 2011, 69.2% companies that had implemented innovation also indicated faster growth. A year later the same indicator showed that only 43.5% of fast-growing companies were implementing innovations, and in 2013 – 42.9%. These findings correspond with Baldwin and Johnson's (1999) research, who found that innovation is positively correlated with company growth. In total, the data showed 30.0% innovative companies and 70.0% companies stuck on the same "production" life cycle.

4. Methods

We model the probability of implementing innovation conditionally on various factors that determine it. We use probit models. This approach, after testing for endogeneity and controlling for potential heteroscedasticity, allows us to construct separate models for four particular years and, after pooling the data, for the entire period 2011–2014. Since in each year the sample of companies was random, we could not use the panel data approach.

We modelled the probability $\mathrm{P}\left(y_i = 1 | u_{ji}, x_{ki}\right)$. Our model took the form:

$$y_i^* = u_{ji}\alpha + x_{ki}\beta + \varepsilon_i, \tag{1}$$

where y_i^* is a latent variable, such that $y_i^* > 0 \Leftrightarrow y_i = 1$. y_i is a binary observed variable:

$$y_i = \begin{cases} 1 & \text{if the i – th company implemented innovation during the last 12 months} \\ 0 & \text{otherwise} \end{cases}$$

u_{ji} is a vector of j control variables and x_{ki} is a vector of k determinants of innovation. α and β are respective parameters, which are not directly interpretable. Thus, we have computed the marginal effects of innovation determinants at means of regressors. We tested the assumption that $\varepsilon_i \sim NID(0, \sigma_i^2)$.

When analysing the influence of economic policy, we encountered a treatment effects problem. In most cases, there was no clear information on whether the policy measure influenced the innovativeness or the other way around. To deal with this simultaneity question, we tested whether particular a policy measure is endogenous. In order to do this, we used the Wald test on the basis of the IV-Probit model (Rivers and Vuong, 1988).

Another potential obstacle in modelling was related to heteroscedasticity occurring after pooling the data for particular years. Due to possible different variances occurring in consecutive years, the error ε_i term may be conditionally heteroscedastic. To include it, we test that $\sigma_i = \exp(v_l\gamma)$, where v_l is a vector of $l = 4$ dummy variables that take the value of 1 in a particular year (2011–2014) and 0 otherwise; γ was a vector of parameters to estimate and test for significance.

During the modelling procedure, we controlled for imperfect collinearity by using the variance inflation factors (VIF) measure. We found that, in the case of many variables, $VIF > 4$. That is why we excluded them from the analysis.

In the final step, we tested for structural change with the Chow test (1960). This allowed us to assess whether the pattern of innovation drivers changed during the years 2011–2014.

5. Empirical results

Table 4 summarises our findings from the probit model. All regressors were jointly statistically significant.[1] There have been no endogenous variables in the final set of regressors. In the pooled model, we found heteroscedasticity – the variances of the error term in particular years differed. We eliminated it by the use of a heteroscedastic probit. Table 4 indicates that the consecutive years differed according to innovation drivers. Thus, on the basis of the Chow test, we rejected the null hypothesis of no structural change in the composition of innovation drivers between the analysed years. The test statistic equalled 4.67, and F(12,956,0.05)=1.76 (p-value<0.01). We can observe a significant structural change in Regional Innovation Strategy drivers of innovativeness in the analysed period. This proves our H3 in general. A description of the direction of this change is presented below.

[1] The full set of variables that were tested as potentially significant is shown in Table 5 in the Appendix. Insignificant variables were removed from the final model. In Table 5, we also show the chi-square test and Crammer's V results. It shows how the institutional factors independently were related to the propensity to implement innovations.

Table 4. Results of the models of innovation implementation by companies in the Podkarpackie Voivodship in Poland

Variable	2011	2012	2013	2014	2011–2014
Const	–2.173 [0.00]	–1,785 [0.01]	–3.850 [0.00]	–5.802 [0.00]	–2.68 [0.00]
Sector	–0.712 [0.09] –0.160	–0.887 [0.03] –0.197	–0.154 [0.63] –0.032	1.172 [0.14] 0.106	–0.317 [0.17] –0.068
Size	0.299 [0.04] 0.060	0.144 [0.26] 0.028	0.443 [0.00] 0.088	0.424 [0.13] 0.052	0.257 [0.00] 0.053
Dynamics	0.488 [0.00] 0.098	0.218 [0.16] 0.042	0.452 [0.02] 0.090	0.692 [0.09] 0.085	0.330 [0.00] 0.067
internal barrier no R&D department	–0.971 [0.00] –0.196	–	–	–	–0.200 [0.09] –0.041
external barrier unfavourable national policy	–	–	–	–0.857 [0.01] –0.105	–
information local institutions	–	–	–	–	0.294 [0.09] 0.059
information consulting companies	0.397 [0.08] 0.080	–	–	–	–
cooperation collaborators	–	–	–	0.980 [0.06] 0.113	–
cooperation barrier financial problems	–	–0.623 [0.01] –0.121	–	–	–0.327 [0.03] –0.068
cooperation barrier information about cooperation	–	–	–	–0.905 [0.05] –0.107	–0.398 [0.06] –0.077
cooperation factor R&D customisation	–	–	0.132 [0.02] 0.261	–	–
cooperation factor information system	–	–	–	–	0.396 [0.06] 0.085
public support	–	–	–	1.525 [0.00] 0.258	0.601 [0.00] 0.130
public type investments	–	–	1.342 [0.00] 0.310	–	–
know institutions regional agencies	–	–	–	0.936 [0.01] 0.115	–

Table 4 – cont.

Variable	2011	2012	2013	2014	2011–2014
know institutions National System of Services	–	–	0.563 [0.04] 0.112	–	–
know financing bank loan	–	0.397 [0.04] 0.077	0.362 [0.08] 0.072	–	0.293 [0.03] 0.060
know financing technology loan	0.393 [0.05] 0.079	–	–	–	–
know information standards and norms	–	0.357 [0.04] 0.069	–	–	–
know information new technologies	–	–	0.367 [0.04] 0.073	–	0.326 [0.00] 0.067
know training product development	0.271 [0.06] 0.055	–	–	–	–
know organisation product development	–	0.356 [0.04] 0.069	–	–	–
know organisation implementation of technology	–	–	–	0.859 [0.02] 0.106	–
year 2011	–	–	–	–	0.330 [0.21] 0.070
year 2012	–	–	–	–	–0.135 [0.60] –0.027
year 2013	–	–	–	–	0.530 [0.05] 0.113
adjusted R^2	0.083	0.063	0.099	0.24	0.073
AIC	452.17	449.90	442.52	164.46	1125.65
BIC	484.08	481.83	478.42	197.34	1198.97
predicted	72.7%	71.5%	74.4%	83.8%	70.9%
overall LR (χ^2)	56.77 [<0.01]	46.02 [<0.01]	66.79 [<0.01]	72.56 [<0.01]	118.11 [<0.01]
endogeneity Wald (χ^2)	1.26 [0.87]	2.03 [0.73]	1.46 [0.92]	3.48 [0.75]	3.23 [0.92]
heteroscedasticity LR (χ^2)	–	–	–	–	1.86 [0.60]

P-values presented in [], marginal effects at means of regressors presented below parameter estimates. '–' means not significant, correlated with other covariates or not applicable.

The sector of ownership statistically significantly determined the probability of innovative activity during the first two years. Within this period, public enterprises introduced innovations more often than private enterprises. This may be due to higher activity of the public sector in terms of using EU funds during the first two years. Public institutions as well as enterprises started to undergo visible changes with a certain lag in comparison to private enterprises. The latter needed to improve their capacity and innovativeness in the early 2000s. This result also means that the Regional Innovation System funds have been used to build the institutional framework for innovation, and these funds have been absorbed to a high extent by public institutions. Overall, in the analysed period, this effect is negative but insignificant. The size of the company improved the probability of introducing innovation. This relation strengthened in 2013–2014 in comparison to the previous two years. Larger companies have certain advantages over smaller companies in the case of innovative activities. They are better informed about financial opportunities. They have better access to specialists and equipment for innovation activity. They are able to delegate employees and resources to innovative activity. Finally, they can create their own R&D departments or outsource it. Another basic factor behind innovation activities in Podkarpackie is the dynamic of enterprise development. The higher the dynamic, the more resources can be spent on the innovative process. Also, the need for innovation is more frequently perceived during periods when revenues and employment increase. This is also positively correlated with the business cycle. During economic expansion, companies prosper, the dynamic of their development increases so as their propensity to innovate. Recessions are periods of slower development and lower propensity to innovate. Our evidence does not support the Schumpeterian creative destruction hypothesis, wherein recessions induce innovation out of necessity. In a poor region, only a good economic dynamic of company development may provide appropriate funds to start an innovative activity. With poor and largely unknown funding sources, most companies start an innovative activity only after having a financial surplus. Necessity is not a valid factor, as most companies do not know how to start an innovative activity.

Interestingly, the economic condition of an enterprise does not determine the probability of implementing innovations. It is rather the dynamic of its development than the initial starting level (whether it starts from a “bad”, “ordinary” or a “good” condition). This proves our H2. Also, the age of a firm does not determine its innovation capability. The results do not change with rescaling the answer range (whether we take continuous periods or for instance 1–10 years, 11–20, etc.). This is a clear indication that more experienced companies do not necessarily accumulate better knowledge.

At the beginning of the analysed period, the lack of an R&D department was a statistically significant internal barrier to innovation activity. Most companies with this department created innovations. Others did not have knowledge on how to start this activity without such a department. From external barriers, in the last year of research, companies indicated an unfavourable government policy. Apart from the EU financing, which was already absent in 2014, when the funding

period ended, Poland does not have many financial instruments or clear policy tools for financing or supporting innovative activity. Among specific negative policy instruments unfavourable for companies, the Public Procurement Act and absence of more specific regulations of financing innovative activity were mentioned. Other factors described are connected to the Regional Innovation System efficiency (H1).

Generally, during 2011–2014, there was no rule as to the share of own and third party resources earmarked for innovation activity or its exact source. There were very few companies that used funds from other than "traditional" sources, for instance venture capital, guarantee funds, loan funds, high-risk capital funds, innovation vouchers, business angels or leasing. Bank loans were by far the most popular. Technology loans did not appear significant until 2011. In the case of bank loans, it was underlined that innovative activity is riskier. Thus, special financial instruments would improve innovativeness. These instruments were scarce in Poland, especially at the beginning of the analysed period. It is also possible that they were not known by companies or poorly understood. At the end of the analysed period, it was not a problem any more.

In the case of innovative activities, companies cooperate among themselves vertically. This includes suppliers, recipients and outsourcers. This type of cooperation is beneficial for both partners. Such cooperation significantly improved innovativeness only in 2014, while earlier certain barriers prevented it. Among them, there were two major causes. The first is related to financial problems or insufficient resources to start cooperation. The second is very limited information regarding cooperation possibilities. Companies from the Podkarpackie region are generally closed (suspicious) and do not easily trust one another if a formal agreement is not signed. The surveyed companies pointed at a few factors that would improve cooperation. The first is an increase in the quality of the offer of R&D institutions and adjusting the offers to the companies' needs. The second is the construction of a system of information on R&D institutions and their offer. It is worth pointing out that many companies did not have R&D divisions and would benefit from outsourcing. Moreover, most of the companies rarely cooperate with universities – despite an institutional network that provides linkage. The reason for limited cooperation is related, according to enterprises, to universities' very high interest in basic rather than applied research (Janiec et al. 2012, pp. 27–28).

At the beginning of the Regional Innovation Strategy programme, firms did not know how to create innovations if they did not already have an R&D department. They needed consulting companies, mainly to introduce them to the creation and implementation of innovations from a practical point of view. Public entities were worse advisors, as they usually did not possess practical knowledge on how to implement innovations. Companies also needed to learn how to cooperate to start innovation activity. At the beginning of the period, companies were not eager to cooperate. At the end of the programme, they reported that lack of cooperation was a significant barrier to innovation activity (H3). They needed to learn to be open and needed to be informed about possible partners and ways of cooperation.

Applications for public support significantly improved the chance of introducing innovations. Innovations often appeared if the company invested funding in fixed assets. The effectiveness of funding depended on the type of innovations: with the highest effectiveness when it comes to introducing product innovations – high-tech equipment. During the early 1990s and early 2000s, when the EU funds were introduced, companies did not know how to use them. Since 2011, however, companies have had sufficient knowledge to access funding. We should also note that in some cases incentives without own contribution created low-quality returns, fizzling out the initiative after the funding contract was terminated. Especially "cluster" initiatives faded out this way.

The information needs of enterprises regarding innovative activities were rather mundane. Companies pointed out the need to formulate standards and norms (only in 2012) and they wanted to formalise knowledge-distribution channels for new technologies. At the same time, they indicated that they did not benefit from new research results and that they preferred applied over basic research. Companies were already aware of new funding and research programmes, including international opportunities. They could move about such topics freely.

6. Conclusions and policy implications

The debate about the effectiveness of policy instruments and funding is everlasting. There is very little empirical work addressing company-level assessment of funding effects. We have presented a case study of a poorly developed region under innovation-stimulating policy. The research was conducted in a Cohesion region that a few years back was not only poor but also dormant in terms of innovation – now, however, the same region has started to be innovative. Our findings can clarify how the Regional Innovation System influences innovation-driven growth. Despite emerging criticism of EU-funding efficiency, we show the case where the institutional nexus had a positive impact on innovativeness.

The hypothesis that the Regional Innovation System induces innovation (H1) was confirmed for very specific instruments. We have found that enterprises benefited from only a few out of the many instruments proposed by the Regional Innovation System. These instruments included especially the tailor-made consulting and financial assistance from local, public and specialised organisations. The more general the instrument, the less attention enterprises paid to it. Thus, we recommend reduction of the budget for general Regional Innovation System activity, while directing the hereby saved funds to specialised, more pin-pointed consultations.

We hypothesised that innovativeness is positively correlated with the dynamics of economic development (H2). In this regard, we have shown that innovativeness and short-term growth are closely and positively correlated. The effects of the Regional Innovation System also changed over time (H3). This means that, in the case of poorly developed regions, diffusion of knowledge has to be carefully monitored to obtain expected results. The companies' needs should be diagnosed, because they change dynamically according to the business cycle phase

and the inflow of funds. Companies with good dynamics of development are more innovative and they have better access to information. The initial level of development does not significantly influence innovativeness.

At the beginning of the development of the Regional Innovation System, (2011), the lack of R&D departments posed a significant barrier to innovativeness. At that stage, the companies did not have adequate knowledge on developing innovative products. Therefore, funding for fixed assets and consulting was very important. During the subsequent stages of development, these barriers became insignificant. Companies have slowly opened up to cooperation. The first level of cooperation was linked to institutions providing information about EU funds and financial possibilities to support innovative processes. Companies generally did not contact public or governmental organisations, but rather worked together with private consulting companies and non-governmental organisations. Enterprises assessed that private consulting companies were better and faster informed than governmental organisations. During the analysed period, companies became more open for vertical cooperation, and awaited cooperation offers.

Companies used traditional funding opportunities to apply innovations – their own sources and bank loans. However, over time – notably in 2014 – more of them recognised other innovation-supporting programmes and started to use them. That is why the EU funds became very desirable. Financial problems were seen as a factor that significantly impaired innovative activities especially at the beginning of the funding period. Thus, during the initial stage, the direct innovation funding may be introduced with more success. Later, new funding instruments on the basis of a bank loan may be introduced to keep the investment efficient. Otherwise firms misuse funds on low-profitability projects.

The application for public funds increased the probability of introducing innovations. However, this was not the case during the initial Regional Innovation System period, but when the system had been in place for longer. It must be noted that the presented results refer to the term "innovation", as the improvement that is made at least on the company level, and not necessarily the introduction of a solution that is new to the region, country or the world. Moreover, developing regions such as Podkarpackie are fund-sensitive because companies have limited access to financing high-risk activities including innovations. We showed that some types of funding did not contribute to permanent improvement, but served only as demand factors, which were clusters. We believe that this type of activity has a chance for success only if it starts with the initiative of enterprises rather than public institutions.

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Appendix

Table 5 Chi-square and Crammer's V (ϕ_c) results for the pooled data

Covariate	χ^2 [p-value]	ϕ_c	Group	Description
Age	112.70 [0.05]	0.27	Age	
Sector	12.20 [0.00]	0.09	Sector of ownership (public / private)	
Size	74.90 [0.00]	0.22	Size	
Situation	38.91 [0.00]	0.16	Self-assessed economic situation	
Dynamics	44.13 [0.00]	0.17	Self-assessed dynamics of growth	
Motive	876.39 [0.00]	0.91	motives for implementing innovation	Improving market position
Motive	846.89 [0.00]	0.90		Improving products and services
Motive	634.78 [0.00]	0.79		Turnaround time
Motive	655.45 [0.00]	0.79		Customer driven innovation
Motive	585.39 [0.00]	0.75		Costs reduction
Motive	527.66 [0.00]	0.71		Meeting the standards
Motive	508.33 [0.00]	0.70		Entering new markets
internal barrier	8.06 [0.02]	0.07	the relationship between the motives and effects for implemented innovation	Insufficient financial resources
internal barrier	10.01 [0.01]	0.08		Insufficient technical equipment
internal barrier	11.46 [0.00]	0.09		Insufficient experience
internal barrier	14.09 [0.00]	0.10		Insufficient information about consumer needs
internal barrier	1.10 [0.58]	0.03		Lack of information about technology
internal barrier	3.47 [0.18]	0.05		No R&D department
internal barrier	4.27 [0.12]	0.05		Insufficient motivation system
internal barrier	4.50 [0.11]	0.06		No support from management
internal barrier	1.20 [0.55]	0.03		Low-skilled workers
internal barrier	1.88 [0.39]	0.04		Reluctance towards innovation
internal barrier	0.45 [0.80]	0.02		Other
external barrier	7.24 [0.03]	0.07	external factors hindering innovation	Difficult access to external financing

Table 5 – cont.

Covariate	χ^2 [p-value]	ϕ_c	Group	Description
external barrier	0.53 [0.77]	0.02		Bureaucracy
external barrier	18.5 [0.00]	0.11		Economic risk
external barrier	6.27 [0.04]	0.07		Unfavourable national policy
external barrier	8.75 [0.01]	0.08		Limited regional demand
external barrier	2.18 [0.34]	0.04		Lack of supporting institutions
external barrier	0.78 [0.68]	0.02		Lack concept of regional development
external barrier	0.63 [0.73]	0.02		Other
plans	196.14 [0.00]	0.35	Plans to implement innovation during next 12 months	
information	0.36 [0.55]	0.02	sources of information about innovation	Contacts with other enterprises
information	8.02 [0.05]	0.08		Public Administration
information	14.33 [0.00]	0.11		Local Development Institutions
information	6.81 [0.01]	0.08		Training
information	9.07 [0.00]	0.09		Ministries
information	19.18 [0.00]	0.14		Consulting companies
financing own	725.74 [0.00]	0.84	The share (in %) of financing innovation from own resources	
financing	279.62 [0.00]	0.48	external means of financing innovation	Loans
financing	201.31 [0.00]	0.40		EU grants
financing	53.15 [0.00]	0.21		Leasing
financing	36.66 [0.00]	0.17		From LGU
financing	47.52 [0.00]	0.20		From Central Government Units
financing	17.13 [0.00]	0.12		Co-financed with other companies
financing	n/a	n/a		Venture capital
financing	6.4 [0.01]	0.07		Guarantee and loan funds
financing	16.92 [0.00]	0.14		Other

Table 5 – cont.

Covariate	χ^2 [p-value]	ϕ_c	Group	Description
cooperation	408.07 [0.00]	0.51	other organisations the companies were cooperating with during innovative activities	Clients
cooperation	91.47 [0.00]	0.24		Collaborators (suppliers/ outsourcers)
cooperation	87.11 [0.00]	0.24		Competition
cooperation	170.24 [0.00]	0.33		Financial institutions
cooperation	108.47 [0.00]	0.27		LGU
cooperation	66.23 [0.00]	0.21		Consulting companies
cooperation	23.96 [0.00]	0.13		Technology transfer centres
cooperation	75.17 [0.00]	0.22		Universities
cooperation	34.42 [0.00]	0.15		R&D Units
cooperation barrier	13.41 [0.00]	0.09	barriers of cooperation with business environment	Financial problems
cooperation barrier	0.49 [0.49]	0.02		Regulations
cooperation barrier	6.22 [0.01]	0.06		Poor cooperation offers
cooperation barrier	0.32 [0.57]	0.15		Lack of measurable benefits from cooperation
cooperation barrier	0.27 [0.61]	0.01		Lack of willingness to cooperate
cooperation barrier	1.26 [0.26]	0.03		No information about cooperation
cooperation barrier	6.31 [0.01]	0.06		Narrow applicability
cooperation factor	0.61 [0.44]	0.02	initiating and development the cooperation with business environment	Development programmes
cooperation factor	1.05 [0.31]	0.03		Customer information system
cooperation factor	0.10 [0.75]	0.01		Institutional development
cooperation factor	8.14 [0.00]	0.07		R&D customisation

Table 5 – cont.

Covariate	χ^2 [p-value]	ϕ_c	Group	Description
cooperation factor	9.26 [0.00]	0.08		Information system about the offers
public support	69.6 [0.00]	0.21	public support for innovation	
public type	68.46 [0.00]	0.23	type of investment made by the use of public funds	Investments
public type	36.3 [0.00]	0.17		Training programmes
public type	14.5 [0.00]	0.11		Consulting
public type	44.74 [0.00]	0.19		Software
public type	9.84 [0.01]	0.09		Licensing
public type	22.93 [0.00]	0.14		R&D
public constraints	0.61 [0.74]	0.02	constraints in raising funds from the EU	Bureaucracy, EU proposals formalisation
public constraints	4.96 [0.08]	0.06		Own contributions to projects
public constraints	4.97 [0.08]	0.06		The cost of developing documentation
public constraints	0.57 [0.75]	0.02		Difficulties linked with proposals
public constraints	0.31 [0.86]	0.01		Short deadlines for grant proposals
public constraints	0.22 [0.90]	0.01		Lack of information about programmes
public constraints	3.28 [0.19]	0.05		Other
cluster	6.15 [0.13]	0.07	Participation in a cluster	
cluster impact	2.9 [0.23]	0.06	the impact of cluster participation on innovativeness	Common standards
cluster impact	2.74 [0.25]	0.06		New organisational know-how
cluster impact	3.62 [0.16]	0.07		New marketing know-how
cluster impact	6.67 [0.04]	0.09		New technology
cluster impact	6.09 [0.05]	0.09		New products
cluster impact	5.86 [0.05]	0.08		Cross-financing
know institutions	28.89 [0.00]	0.14	knowledge about institutions supporting innovativeness	Ministry of Regional Development
know institutions	21.97 [0.00]	0.12		Ministry of the Economy

Table 5 – cont.

Covariate	χ^2 [p-value]	ϕ_c	Group	Description
know institutions	32.79 [0.00]	0.15		Polish Agency of Enterprise Development
know institutions	41.54 [0.00]	0.17		Regional Development Agencies
know institutions	16.43 [0.00]	0.1		Regional Chamber of Commerce
know institutions	30.73 [0.00]	0.14		Business Incubators
know institutions	33.56 [0.00]	0.15		National System of Services
know institutions	45.05 [0.00]	0.17		Centres for Innovation and Entrepreneurship
know institutions	20.33 [0.00]	0.12		EU Science Diffusion Centres
know institutions	16.86 [0.00]	0.11		National Contact Point
know institutions	18.79 [0.00]	0.11		Technology Parks
know institutions	12.15 [0.00]	0.09		Technology Transfer Centres
know consult	30.18 [0.00]	0.14	knowledge on consulting opportunities about innovation	Business Plan
know consult	53.21 [0.00]	0.18		EU Proposals
know consult	34.00 [0.00]	0.15		Institutional forecasting
know consult	50.64 [0.00]	0.18		Scientific expertise
know financing	25.26 [0.00]	0.13	knowledge on support instruments supporting innovation	Bank loan
know financing	49.06 [0.00]	0.18		Grants for targeted projects
know financing	49.03 [0.00]	0.18		Technology loan
know financing	33.77 [0.00]	0.15		Venture Capital
know financing	35.27 [0.00]	0.15		Innovation vouchers
know financing	37.55 [0.00]	0.16		Business Angels
know information	80.98 [0.00]	0.23	knowledge and use of information about support for innovation	Standards and Norms

Table 5 – cont.

Covariate	χ^2 [p-value]	ϕ_c	Group	Description
know information	83.87 [0.00]	0.23		New Technologies
know information	65.45 [0.00]	0.21		Scientific Discoveries
know information	50.56 [0.00]	0.18		EU sponsored research
know information	54.28 [0.00]	0.19		National and International Grant Projects
know training	54.27 [0.00]	0.19	knowledge and use of training supporting innovation	Proposal Writing Training
know training	46.44 [0.00]	0.17		Project Management Training
know training	78.04 [0.00]	0.23		Product Development Training
know training	64.49 [0.00]	0.20		Intellectual Property Training
know organisation	28.39 [0.00]	0.13	knowledge and use of organisational support instrument for innovative activities	Development of a new product
know organisation	54.57 [0.00]	0.19		Implementation of new technologies
know organisation	38.73 [0.00]	0.16		Patens/licensing
know organisation	26.94 [0.00]	0.13		Scientific discoveries
know organisation	24.83 [0.00]	0.13		Commercialisation of Technology