

TECHNOLOGY AND SPACE IN INNOVATION PERFORMANCE OF POLISH REGIONS

Arkadiusz Świadek, Ph.D.

Institute of Enterprises Economics and Organisation Faculty of Economics and Management University of Szczecin Mickiewicza 64, 71-101 Szczecin email: arkadiusz.swiadek@uoo.univ.szczecin.pl

Received 16 October 2007, Accepted 19 December 2007

Abstract

Space and technology are key determinant of innovation performance in industry not only in Poland, but also in developed economies. This research proved that space, time, technology and size of industrial enterprises are important elements of every regional innovation system. For this reason, those factors should be given appropriate attention while developing innovation strategies.

Keywords: innovation; technology; space; industry; region.

JEL classification: O18, O31, R12, R39, R58.

Introduction

Efficiency of innovative systems on the regional level should be strongly determined by spatial and technological diversity. Such conclusions have been reached by authors of numerous theoretical and empirical studies, although those issues are discussed more often in the foreign rather than domestic literature¹. Since in developed countries the geographical and technological factors affect inter- and intraregional diversity of innovation performance, a question arises whether such relationships refer also to our country. For this reason, the research presented in this study involved identification of spatial and technological convergence and divergence within innovation processes carried out in Polish regions.

The research hypothesis at this stage stated that inter- and intraregional spatial and technological diversity was significant in the context of innovative processes carried out. The aim of the research, on the other hand, was adopted as an attempt to identify the factors which explain different levels of innovation performance in individual regions.

The sample included 73,516 business entities operating in the industry sector in all the 16 provinces, which proves that the group was representative – the study itself is unique for the whole country. The data was processed in four areas: general and detailed, and each of them in absolute and relative figures². An initial analysis was carried out for absolute figures, taking into account the actual condition of Polish industry.

To avoid mistakes related to considerable concentration of innovation expenditures and industrial companies in several provinces, the same ranks were assigned to each province. Technically, it involved using percentages rather than absolute figures. The last area of research focused on the selected detailed data, identified in the form of a matrix, which allowed observation of specific divergences between the locations, technology, size, and broad innovation performance.

The companies subject to analysis were established before the year 2003, and continued their industrial operations as of the year 2006. The independent variables included: spatial diversity (agglomerations, intermediate areas, outskirts), technology (High – HT, Medium-High – MHT, Medium-Low – MLT, Low – LT), size of the company (big, medium-sized, small). Dependent variables were defined as the shares of individual regions in the total innovation expenditures in the years 2002, 2003 and 2004. In the methodological part of the research, the key role was played by the analysis of interregional correlations within the variables adopted (4,273 correlations were analysed).

It is common knowledge that there is a strong relationship between the innovation expenditures in the regions and the number of companies operating in those regions. It is typical of mass phenomena that in the places where industrial companies are concentrated, we are witnessing also concentration of innovations expenditures. What happens, however, if each region is assigned an equal rank and the Mazovian Region becomes a match for the Western Pomeranian Region? It is then that we obtain an objective impact of spatial diversity in the regions on their innovation performance and a reply to the basic question about the character of that impact.

Basing on the analyses carried out, the author has reached a number of relevant conclusions that allow classification of regions according to various criteria, and provide opportunities to shape development paths both on the national level and in the individual cases.

1. Technological level of the regions and their innovative activities

Concentration of companies representing different technologies in the regions is closely related to their innovativeness. In the basis year (2002) the strongest relationships are observed for the innovation performance of medium-high-technology and medium-lowtechnology sectors, followed by high-technology and low-technology sectors. Over time, however, those relationships evolve. Firstly, the relationship between the technological structure of the region and its innovation performance becomes stronger over time. Conclusion: the higher the share of companies representing different technologies in the region, the better the region's innovation performance.

Table 1. Matrix of correlations between the shares of companies representing different technologies in Poland (by regions) and their shares in innovation expenditures in the years 2002-2004

	Innovation	Innovation	Innovation		
Technology level	performance in	performance in	performance in		
	2002	2003	2003		
High technology	0.738	0.862	0.959		
Medium-high technology	0.840	0.929	0.960		
Medium-low technology	0.826	0.913	0.951		
Low technology	0.701	0.851	0.929		

Source: own study based on the data published by the Central Statistical Office and Teleadreson.

The strongest increase in correlation is observed for the sector of high and low technologies, and a weaker one – for medium-high and medium-low technologies. The impact

of the structure of companies from the viewpoint of the technology used becomes a model relationship after three years. This relationship suggests that the strongest correlation between the region's innovation performance and the structure of companies should be observed for high technologies, followed by medium-high technologies, and then by medium-low and low technologies. In other words, the more high-tech companies in the region as compared to other regions, the better its innovation performance – with a three-year delay. It should be noted, however, that those relationships remain strong for each of the analysed group of entities.

Table 2. Matrix of correlations between the shares of companies representing different technologies in the region, and their shares in innovation expenditures in the years 2002-2004

			J
	Innovation	Innovation	Innovation
	performance	performance	performance
	in 2002	in 2003	in 2004
High technology	0.579	0.546	0.640
Medium-high technology	0.570	0.464	0.362
Medium-low technology	0.069	-0.098	-0.189
Low technology	-0.505	-0.340	-0.264

Source: own study based on the data published by the Central Statistical Office and Teleadreson.

It follows that the measure which takes into account the technological structure of the region is a much better one when analysing the impact of technology on the region's innovation performance. It reveals the nation-wide impact of the share of companies representing individual technologies in the region on the level of its innovation performance. The measure which was interpreted before described only relationships between the number of companies and the innovation expenditures in the regions. This time the analysis is extended to cover intra-structural relationships in each of 16 provinces. Previously it was shown that the more versatile the companies were in terms of technology in the region, as compared to other provinces, the higher the region's share in innovation expenditures. In the year 2002 the highest correlation was observed for the sectors of high and medium-high technologies, which provides evidence for a relationship between the technological structure of the region and its innovation performance in the scale of the whole country. A relationship of an opposite character can be observed for low-tech companies, which means that their higher share in the total number of companies in the region is accompanied by worse innovation performance thus pointing to non-technological parameters of regional development under its worsening industrial competitiveness. Lack of correlation is observed for medium-low technologies, which proves that the number of this type of companies in the region and the region's innovation performance do not affect each other.

Next to the statistical depiction of the relationship between technology and innovation performance, dynamic elements were take into account, too. It involved an analysis of the relationship between the structure of technology in regions and innovation performance additionally for years 2003 and 2004. After two years, the impact of those relations did not change its direction but the strength of that impact did change. We are still witnessing a positive impact of high-tech and medium-high-tech companies on innovation performance, and a negative impact of low-tech and medium-low-tech companies. With time, however, the impact of high-tech companies increases while the impact of medium-high-tech companies weakens. At the same time, the negative impact of low-tech companies decreases and the impact of medium-low companies becomes stronger. For the long run, the share of mediumhigh-tech and low-tech companies on the region's innovation performance is limited, whereas the impact of the share of high-tech (strongly positive) and low-tech (clearly negative) companies increases. In other words, the regions which did not generate appropriate "critical mass" to lay grounds for innovative microsystems will suffer from limited technological competitiveness in the future. Until the region becomes self-supporting within the high-tech sector, it will be destined to marginalisation unless it has a choice of alternative strengths³.

To sum up, the above-presented data and methods of its processing allowed formulation of a number of significant conclusions. Even though the research was based on the national data, it had a regional character and that was the direction selected for constructing most interpretations. Basing on the results, the following general theses have been formulated:

- 1. The technological structure of the region is a reflection of its innovation potential.
- 2. In bigger populations, there is more chance to generate an innovative entity, regardless of the level of technology it represents, although it will be observed for high tech rather than medium-high-tech, medium-low-tech or low-tech companies.

The data suggests not only a strong relationship between the technological structure and innovation performance, but also points to the high tech sector as the one that can boast the highest positive and still increasing dynamics. A falling positive potential of the medium-high-tech sector over time, accompanied by an indifferent negative influence of medium-low technologies and a stronger negative impact of low technologies, verging on a threat, becomes a tip for national and regional decision makers suggesting preferences in innovation stimulation.

In our country's situation, there are more and more opportunities for better innovation performance of the regions related to the number of companies, regardless of their technological level. It should be clearly stressed that this increase is not of an absolute character, since its dynamics should exceed the dynamics observed in other regions of the country, which at the moment can be seen as hardly feasible for underdeveloped regions. As a result, we can conclude that the differences in the development will become stronger rather than weaker.

2. Spatial system and innovation expenditures in regions

While analysing the dependent variable as a representative of innovation expenditures, the first and foremost conclusion seems to be that there are strong and positive relationships between that variable and the number of companies classified by technology, size and location. In the regions where there are more industrial entities, regardless of the factor accepted, the amount of the expenditures in question will be much higher, following general regularities observed for mass phenomena. Basing on the results, we can also observe that in the case of intermediate areas and outskirts those correlations are much weaker than those observed for agglomerations, which indicates a stronger and at the same time positive impact of the latter on the amounts which companies spend on innovation. It is also noteworthy that the positive impact observed for agglomerations and outskirts becomes stronger over time, whereas for intermediate areas it becomes weaker.

1 1	ne years 2002 2001 m	the high tee		absolute ligui
		2002	2003	2004
	Agglomerations	0.69	0.83	0.94
	Intermediate areas	0.91	0.82	0.77
	Outskirts	0.67	0.86	0.93

Table 3. Matrix of correlations between location of a company and innovation expenditures in the years 2002-2004 in the high-tech sector (absolute figures)

Source: own study based on the data published by the Central Statistical Office and Teleadreson.



Fig. 1. Number of high-tech companies in Polish regions and their shares in national innovation expenditures

Source: own study based on the data published by the Central Statistical Office and Teleadreson database.

Table 4. Matrix of correlations between location of a company, level of its technology and innovation expenditures in the year 2004 (absolute figures)

and milovation experienteres in the year 2004 (absolute rightes)					
	LT	MLT	MHT	HT	
Agglomerations	0.94	0.94	0.95	0.94	
Intermediate areas	0.75	0.81	0.78	0.77	
Outskirts	0.79	0.87	0.85	0.93	

Source: own study based on the data published by the Central Statistical Office and Teleadreson.

Table 5. Matrix of correlations between location of a company, level of its technology and innovation expenditures in the year 2004 (as %)

	LT	MLT	MHT	HT
Agglomerations	0.59	0.36	0.35	0.34
Intermediate areas	-0.21	-0.11	-0.10	-0.14
Outskirts	-0.53	-0.33	-0.32	-0.35

Source: own study based on the data published by the Central Statistical Office and Teleadreson database.

Table 6. Matrix of correlations between location and size of company and innovation expenditures in the year 2004 (as %)

	Small	Medium-sized	Big
Agglomerations	0.40	-0.43	-0.21
Intermediate areas	0.44	-0.46	-0.22
Outskirts	0.02	-0.61	-0.48

Source: own study based on the data published by the Central Statistical Office and Teleadreson database.

While analysing similar data, but as percentages, we may conclude that the impact of the individual criteria is not so strong as before, which provides evidence for a significant impact of the region's potential (in absolute figures) on its innovation performance.

In the case of technological diversity, we can observe that whereas an agglomeration has a significant impact on the region's innovation performance, location of the company in the outskirts relevantly reduces innovation expenditures, while the intermediate areas become indifferent in terms of such impact. Provinces where most industrial companies are located in agglomerations, at the expense of the outskirts, will therefore lead in innovation expenditures.



Fig. 2. The tendencies for populations of high-tech (left box) and low-tech (right box) companies located in the outskirts in Poland Source: own study based on the data published by the Central Statistical Office and Teleadreson.

The more high-tech and medium-high-tech companies are located in agglomerations, at the expense of medium-low-tech companies, the higher the expenses on new technologies in the region; yet it should be noted that the relevance of the medium-high-tech sector becomes weaker over the time. In the case of other areas, it is also the high- and medium-high-tech sectors that have the strongest impact on innovation, yet this time at the expense of low-tech companies. It is also noteworthy that in a short run the impact of the medium-high-tech sector on innovation expenditures is strong but weakening over the time. An opposite tendency is observed for high technologies.

From the viewpoint of interrelationships between the company size, its location and amount of innovation expenditures, we can clearly identify certain correlations. An increase in the number of companies located in the outskirts reduces the expenses in question, i.e. companies may be more reluctant to spend the money. Companies located in intermediate areas contribute nothing significant in this aspect. Agglomerations, on the other hand, clearly stimulate companies to be innovative, regardless of their size.

Small enterprises stimulate innovation in the region, as the increase in their number, at the expense of medium-sized and big enterprises, is strongly related to the amounts spent in the region on innovation. In the regions with an increasing number of big enterprises, however, the expenses are lower; moreover, this relationship becomes stronger over time.

 Table 7. Matrix of correlations between the location of a company, level of its technology and innovation expenditures in 2004 for small enterprises (absolute figures)

1				<u>`</u>
	LT	MLT	MHT	HT
Agglomerations	0.94	0.94	0.95	0.94
Intermediate areas	0.77	0.83	0.81	0.78
Outskirts	0.81	0.87	0.87	0.93

Source: own study based on the data published by the Central Statistical Office and Teleadreson.

Table 8. Matrix of correlations between the location of a company, level of its technology and innovation expenditures in the year 2004 (as %)

Technology	Company size Agglomerations Outs			
reemology	Company size	Aggiomerations	Outskiits	
HT	small	+	-	
	medium-sized	+	0	
	big	0	+	
MHT	small	+	-	
	medium-sized	+	-	
	big	+	-	
MLT	small	+	-	
	medium-sized	+	-	
	big	+	-	
LT	small	+	-	
	medium-sized	+	-	
	big	+	-	

Source: own study based on the data published by the Central Statistical Office and Teleadreson.

An analysis of detailed data allows several interesting observations to be made. Firstly, in each technology group, regardless of the location, an increasing number of small enterprises implies higher innovation expenditures. Secondly, a higher number of big enterprises representing high and medium-high technologies in agglomerations determines *in plus* the dependent variable in question; in intermediate areas the key role is played by medium-low technologies – an increase in the number of those entities implies again higher innovation expenditures. In other cases no clear tendencies are revealed. Thirdly, in relative figures, it has been shown again that agglomerations play an important part in stimulating innovation through spatial concentration, which is not the case in the outskirts. No significant impact has also been recorded for intermediate areas. There is, however, one exception among those general tendencies – a strong correlation for big high-tech enterprises and the outskirts (correlation coefficient reached 0.92), whereas lack of such a relationship is noted in this group of enterprises for agglomerations (correlation coefficient at 0.06). Given the small size of the analysed sample, the results should be interpreted with due caution as further detailed research is required.

3. Conclusions

The analyses have provided a number of valuable conclusions within innovation processes in Poland and its regions. First and foremost, the thesis was verified positively about the relevance of the spatial and technological factor to shaping innovation performance of each region in the country. It means that system attempts to stimulate (encourage) development of new products and technologies should take into account the level of development of the agglomeration, intermediate areas and the outskirts and their technological profiles in individual provinces. The national or regional policy in this area should therefore not underestimate the existence of strong interactions between geographical and demographic conditions thus providing opportunities for extending or reformulating the existing innovative strategies to cover the analysed issue.

An absolute measure of innovation diversity of the regions clearly reveals that bigger populations are characterised by a higher ability to spend money on innovation. Taking into account their high development potential, those regions have a natural ability to increase their competitive advantage over weaker provinces. Given those circumstances, the only alternative for weaker provinces is to reformulate their development strategies and orient them at innovation. Otherwise, without any strengths, the role of underdeveloped regions will become still weaker. Another solution may be a high level of absorption of EU resources, which according to various programmes can lead to a slow reduction of structural differences between the regions.

In the case of funds earmarked for innovation, except for the high-tech sector, an important role was played also by medium-high technology, the difference being the fact the innovation expenditures are this time limited by an increasing share of low-tech enterprises. A dynamic approach indicates increasing relevance of the high-tech sector (positive impact) and the medium-low-tech sector (negative impact), and falling significance of the medium-high and low-tech sectors. It means that except for spatial and technological diversity, there are also time differences.

Developed agglomerations, regardless of the region, contribute to high dynamics of innovation whereas an increasing relevance of the outskirts leads to marginalisation of the province in the map of Poland. In other words, stimulation of innovation in the outskirts is pointless unless the region can boast developed agglomerations. High efficiency of innovation can be therefore obtained when supporting the development of the outskirts in Mazowieckie, Śląskie, Wielkopolskie, Dolnośląskie and Małopolskie Provinces, or agglomerations in other parts of Poland. This conclusion seems to be logical in the context of agglomeration economics and transfer of tactical knowledge, since underdeveloped provinces have limited opportunities to transfer the knowledge created in agglomerations where that knowledge is more scarce than in developed regions and becomes an object of diffusion to the outskirts – low industrial culture.

Regardless of the location, an increasing share of high- and medium-high-tech companies in the region at the expense of low- and medium-low-tech ones contributes to higher innovation expenditures. Stronger relationships are observed for agglomerations, however, than for the other areas. An increasing share of small enterprises in a province has a positive impact on the amount of funds spent on development of new products and technologies, which proves that it is small rather than medium-sized or big enterprises that hold the key to the level of those expenditures.

The absolute figures suggest that the regions where industry is concentrated in agglomerations generate higher innovation expenditures, irrespective of the technology and company size. Intensification of expenses per an innovative enterprise is higher for high tech companies in agglomerations, and for medium-high tech companies – in intermediate areas and the outskirts.

This study has provided the evidence for a strong relationship between distribution of the industry in space, its level of technological development and structure by size on the one hand and innovation expenditures on the other. Agglomerations, unlike the outskirts, play a key role in each region in accelerating innovative processes, whereas intermediate areas have not proved significant in this aspect so far.

Innovation is stimulated mostly by high- and medium-high-tech industrial enterprises, even though the relevance of the latter becomes weaker over the time. An opposite tendency is observed for low- and medium-low-tech sectors.

An increasing share of small enterprises in a region contributes to improvement in its innovation performance both in terms of finance and tangible assets. A negative impact is observed for both big and medium-sized enterprises. When analysing absolute figures, much stronger interactions were reported between individual variables than in the case of breakdown data, which does not affect, however, the fact that both mass and structural approach together determine the efficiency of innovative activities undertaken in Polish regions.

The information provided in this study should contribute to a better quality of innovation strategies developed in Poland, as so far none of those existing has taken into

account the spatial determinants of stimulating innovation performance. It is also a voice in the discussion to be heard by central authorities who shape general guidelines for supporting development of new products and technologies and make attempts to coordinate activities at this level of aggregation.

Notes

- ² The research was carried out for all the Polish regions, so each finding should be always related to either other provinces or average values (relative figures). An increase or decrease observed for selected values refers always to the intensity of changes in other regions. For this reason, a positive impact of individual variables cannot be observed unless the changes are more intense than those observed in other provinces.
- ³ Such textbook-like variety can be observed for Spain, and especially the Balearic Islands. Source: Munoz, Espinoza de los Monteros, Diaz (2000).

References

- Audretsch, B.D. (1998). Agglomeration and the Location of Innovative Activity. Oxford Review of Economic Policy, 14(2), 18-28.
- Edquist, Ch., Erikson, M.L. & Sjorgen H. (2002). Characteristics of Collaboration in Product Innovation in the Regional System of Innovation of East Gothia. *European Planning Studies*, 10(5), 563-581.
- Frenkel, A. (2000). Can Regional Policy Affect Firm's Innovation Potential in Lagging Regions? *The Annals of Regional Science*, 34, 315-341.
- Munoz, E., Espinoza de los Monteros, J. & Diaz V. (2000, 7-8 January). Innovation Policy and the Concept of National Innovation System in the Spanish Context: Are they Ghost Images or Real Entities? Strasbourg. Converge Project SOE2-CT98-2047, p.47.
- Simmie, J., Sennett, J. & Wood, P. (2002). Innovation in Europe: A Tale of Networks, Knowledge and Trade in Five Cities. *Regional Studies*, 36(1), 47-64.

¹ Simmie, Senett, Wood (2002), Audretsch (1998), Edquist (2002).