TECHNOLOGICAL PARKS AS AN ELEMENT OF INNOVATION SYSTEMS INFRASTRUCTURE

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Summary: The paper discusses the infrastructure of innovative systems existing and developing in Poland. It presents the applied methodologies of measuring and assessing the innovative activities based on indicators and an original approach to the way of examining, evaluating and classifying the organizations constituting the infrastructure of innovation systems. For that reason a bi-parametrical model was used, according to which the organizations studied are presented as points in the plane. A certain type of map is created in the form of a matrix, which in a simple way illustrates a functional location of the organizations examined. In the bi-parametrical model of description one avoids evaluating according to the linear order, and while comparing the organizations one can consider their uniqueness.

Keywords: Innovative activities, innovation systems infrastructure, technological parks, innovative activities measurement.

1. Introduction

The main driving force of the productivity growth in the developed economies is the application of innovation based on: knowledge, research and development (R+D), entrepreneurial attitude, creativity, and education. Innovation becomes the essential measure of competitiveness and the key element increasing the efficiency and economic growth, especially during the rapid technological changes. Innovation allows to outdistance the competitors-it is demonstrated by new products and services, it opens new markets, invents new ways of identifying and fulfilling consumers' needs. Innovative activities generate a significant added value for industries and services and contribute to strengthening the competitive powers of national and regional economies on the international market. The development perspectives of highly-advanced countries indicate that building the competitive dominance based on knowledge and innovation can guarantee long-lasting development as well as creating new and better jobs.

At present Poland is at a specific period of evolving. The present-day competitive dominance based on low labour costs becomes less important. It is inevitable to build new dominance based on knowledge and innovation, which are the main factors of the long-term economic growth. From that perspective it is vital to foster the innovative activities of business organizations, which can be defined as the entirety of scientific, technological, organizational, financial and commercial activities whose aim is to develop and implement innovations [1].

Attention should be directed to the fact that innovative activities (R&D, implementation and commercialization of the results of research and developmental work, etc.) occurs as part of complex structures, which do not constitute simple closed systems within one firm. Conducting scientific research and implementing its results is based, to a greater extent, on network cooperation of universities, scientific and research centres, business organizations, and institutions supporting innovations, entrepreneurship, and technology transfer. Studies show that research and innovative activities as well as implementing new products and solutions requires a new approach including the Open Innovation principle [2]. While applying the Open Innovation approach business organizations should use their own ideas as part of their research work, as well as applying external solutions. They should also make use of the internal and external ways of facilitating the market. It constitutes key conditions for meeting technological expectations and challenges.

2. Institutions of the innovative business environment

Organizational structures forming innovation systems aim at conducting innovative activities. In order to meet the challenge of the Open Innovation concept they form teams, whose members come usually from different entities with a different organizational structure and operate within different legal and ownership systems. The innovative activities are carried within a structure which can be described as multidisciplinary and includes enterprises with high and medium technologies, universities, research and development entities, business environment institutions, among which are: centres of excellence, centres for technologies transfer, technological parks and incubators, centres for advanced technologies, clusters, funds such as loan, venture capital, seed, and guarantee, etc.

The organizations constituting the innovation and entrepreneurship centres play an important role within the above-mentioned structures. They facilitate technology transfer and actively participate in the formation of environment which can absorb innovative solutions, expect the new and thus generates conditions in the society for producing innovative products, which demands entrepreneurial attitudes, oriented towards the application of knowledge. The properly shaped environment enforces the development of innovative solutions, needless to say, those which are demanded at a particular time period (Pull strategy). Their implementation is in favour of development, because innovative products find consumers. In this way a low effective Push strategy is replaced, in which the innovative solutions creators attempt to “push” them into the market. These solutions at that moment are often not expected by the market [3].

Analyzing the issues of innovation implementation and diffusion in professional literature, one can see that an insignificant percentage of population is interested in innovations while the majority adopt a passive attitude. E.M. Rogers divided the population into five groups [4]: innovators and early followers (about 16% of the population, in terms of sociology includes young people, well-educated, well and very well-off), early majority of followers (34% of the population, these are individuals of average social status, who based their decisions on the opinions of innovators and early followers), and late majority of followers and stragglers (about 50% of the population, elderly people with lower education and lower income). The analysis of the size of the groups of innovators and early followers indicates clearly how conservative in terms of innovation the society is, according to Rogers’ model. The pro-innovative policy in particular regions should be active, complex and directed at young, well-educated generations.

The structure and range of tasks undertaken by particular institutions is determined by: the aims of local/regional development structure, cultural background, economic situations and the economic development level. At the same time there exists no universal organizational model functional for the institutions discussed. The operation of each is dependent on: reserves obtained from the shareholders, assumed mission, professional competence and qualifications of workers, an opportunity to gain external means for statutory operation and their reception by the local community. Concentration of enterprises and business related services in a closed area creates "synergic effects", which in conjunction with the R&D activities and venture capital possibility, may be transformed into innovative environment. The contemporary network business needs the dynamic surroundings generating innovative abilities.

Functionally discussed institutions focus their activities in areas significant for the development processes where the innovative processes and entrepreneurship are supported in the form of:

- assistance in the transfer and commercialization of the new technologies within the scope of the technology transfer centres and technological parks,
- stimulation and management of knowledge and technology transfer between universities, research and development entities, enterprises and markets,
- spreading knowledge and skills through consultancy, training courses, and information in the form of training and consultancy centres,
- financial help in the form of para-bank loan funds, seed funds and guaranteed loans, network of business angels offered to individuals opening their own business and "young" firms without any loan history,
- assistance with creating new, innovative firms in the surroundings of scientific institutions and universities, started by the students, graduates, doctoral students, and research workers in the pre-incubators and academic entrepreneurship incubators,
- generous help in consultancy, technical issues and accommodation for the newly created enterprises in the entrepreneurship incubators and technological centres,
- clusters of enterprises and the animation of the innovative environment by joining business services and various forms of assistance for firms in a particular adapted area as part of the technological parks, business zones, and industrial parks.

Establishing this kind of centre may be supported by the administrative decisions and economic incentives, however their development and effective use requires engagement of well-educated people, young, full of ideas and courage to undertake innovative actions. Large urban centres have no problem with that as opposed to smaller towns, especially the poor "eastern wall", where the scarcity of effective actions as part of the social policy cannot stop young people with high intellectual potential from migration.

The analysis of the innovation and entrepreneurship centres location and operation in Poland indicates the tendency to concentrate the supportive activities in the regions with high economic potential and strong market. Subjects in the peripheral regions have, as a rule, weaker staff and poorer facilities. Thus the support system developing in Poland activates the areas which are already dynamic, and leads to even deeper development disproportion from a spatial perspective. Over the next years one should not expect further growth in the number of centres. Rather it is desirable that they become more professional in their operation. New institutions should evolve surrounded by science and research.

3. Innovative activities examination

The growing importance of innovations in the process of economic development implies the necessity for doing research of innovative activities. The research results are more and more often taken into consideration in economic and developmental programmes at central and regional levels. That requires the development of research tools and methods of monitoring innovative processes in the economy, in order to, for example, select areas and the range of state intervention, evaluate the efficiency of the development strategies, and select proper instruments of support. Research is also conducted to improve the performance of the centres and measure their effectiveness. The results are extremely important to the management and employees of the centres.

Well-known methodologies of research concerning the innovative activities are mainly based on statistical descriptions. However, the measurement of the innovative activities level seems to be still imperfect compared to the measurement of economic variables such as production, investment, trade, or employment. Technological innovation is a very diversified economic category as it refers to products of different technological, economic and social importance (as a jet engine, microprocessor, corkscrew). Completing technological innovations with organizational and marketing ones, additionally, makes this category complicated [5].

Two methods are used in the measurement of innovative activities. One is the so-called object-oriented method (measuring the number and character of the existing innovations) and the other is the subject-oriented method (research of enterprises which introduced innovations). In the object-oriented approach the data is gathered from the statistical research and company reports. The subject-oriented approach provides more information on individual innovation than the object-oriented method and patent research, but it informs of fewer number of innovations. Moreover, the applied in it sample selection is arbitrary and thus international comparability of the collected data is low.

The alternative and commonly used method of collecting data on innovations relies on surveying companies, referring to different aspects of the innovative process in the industry and service sector and the size of centres dedicated to industry, as well as factors strengthening or preventing innovation, effects of innovation, information sources for innovation, company activities and innovation diffusion. Due to applying subject-oriented approach it is easier to consider innovation with reference to other economic variables (such as production size, value added, employment) both at company and trade levels. This method is recommended and described by the Oslo Course Book [6].

At present the most important innovation indicators used are:

- Technological innovation: share in the examined population of firms which introduced a product, process and technology innovation in recent years.
- Non-technological innovation: share of companies which introduced marketing and organizational innovation.
- Contribution: overall expenditure on innovation, share of companies realizing R&D, share of companies realizing R&D on regular basis.
- Output: share in the product innovation turnover, share in the turnover of innovation of products new on the market.

Moreover, share of active companies in the international markets, cooperating in the innovative activities, cooperating with public scientific institutions, which received public support for innovative activities and applied for patents [7].

On account of the level of methodology development, the ways of collecting and analyzing data, in branches constituting the statistics of science, technology and innovation two groups of issues arise [5]. One group includes branches with well-developed, consolidated standard methodology. In the majority of countries data from these branches are collected and analyzed according to the commonly accepted international methodological instructions. These branches include:

- statistics of the research and development activities (R&D),

- statistics of patents,
- statistics of innovation (in particular, the so-called subject-oriented method),
- balance of payments in the field of technology,
- high technology products and fields, and knowledge intensive services,
- indicators referring to human resources for science and technology,
- bibliometrics.

The other group includes branches, whose methodology is at the development stage, and the indicators and data are not fully comparable (because in different countries they are collected according to different and constantly changing methodology). This group usually includes the following issues:

- application of advanced productive technologies,
- information and teleinformation technologies,
- indicators based on information from technological magazines (particularly concerning the "measurement": of innovations, e.g. LBIO indicators),
- non-material investment,
- "measurements" of organizational changes and non-technological innovations in companies,
- technology development forecast,
- studying the approach of society towards science and technology.

The indicators included in the first above-mentioned group can be divided into two basic categories. The first category, the so-called input indicators, refers to the resources allocated to the R&D activities. The aim of the indicators from the second group, the output indicators, is to measure the effects of activities and evaluate how the scientific and technological activities affect the operation of economy (impact indicators).

It is difficult to study the innovative activities in institutions belonging to the system of innovation. For example, technological parks operating in the world for many years, have introduced into their management system processes analysing the effects of their performance. Research is conducted on the basis of groups of indicators, for example [8]:

- key effectiveness indicators: value added for the local economy, sales and export increase, new jobs (including those requiring special qualifications), new investment (including: R&D activities, training, marketing, infrastructure), labour effectiveness changes (value added gross per person),
- medium-term indicators of effectiveness: number, survivability and pace of growth of start-ups, a number of foreign investments (number of jobs generated), technology exchange, attracting and retaining graduates, networking (between subjects inside and outside the park), starting business and providing services, funds gained for the activities of the park,
- short-term effectiveness indicators, the sum of income and expenditure, the percentage of the rented surface, number of firms within the park, the number of firms incubated, number of events (conferences, training courses, etc.) and the number of participants, number of firms requesting support, number of business contacts, number of companies, which were given support, number of links with scientific centres.

International Association of Science Parks studies the effectiveness of parks with [8]:

- a matrix of indicators divided into – financial and non-financial, internal and external, short and long-term. The matrix of key indicators is divided into five categories: commercial dimension, shareholder's perspective, owner's perspective, brand and reputation, internal business processes,

- Strategigram, an Internet tool used for studying the effectiveness and supporting strategic management of parks, based on indicators assigned to seven theme axes: Axis 1: Location and environment, Axis 2: Technology transfer, Axis 3: Target group of enterprises, Axis 4: Specialization level, Axis 5: Target markets, Axis 6: Networking, Axis 7: Management model.

Polish technological parks were put through benchmarking tests by commission of the Polish Agency of Enterprise Development in the years 2008 and 2010, with the application of indicators describing their activities. In the year 2010 the analysis was based on the Balanced Scorecard, a strategic management tool, invented by Robert Kaplan and David Norton and adapted to suit the specificity of parks. The parks were assessed within eight areas: the source of funding the technological park, operation activities, designing and creating the park, operation effectiveness, benefit for the park residents, network links between the park and residents, creation and transfer of knowledge, competence and experience [12].

4. Assessment method and classification of innovation and entrepreneurship centres

The paper [3] presents an original methodology of evaluation and classification of innovation and entrepreneurship centre on the basis of two parameters: the level of technology and the innovative environment development. The selection results from the fundamental tasks assigned to the innovation and entrepreneurship centres. A specific map in the form of a matrix of ranks is created on the basis of the two parameters (fig.1). The map shows three ranks related to the level of technology (T-1,T-II, T-III) , and three ranks related to the innovative environment (R-I, R-II, R-III). Thus nine ranks of development of the objects classified (innovation and entrepreneurship centres) are defined on the map.

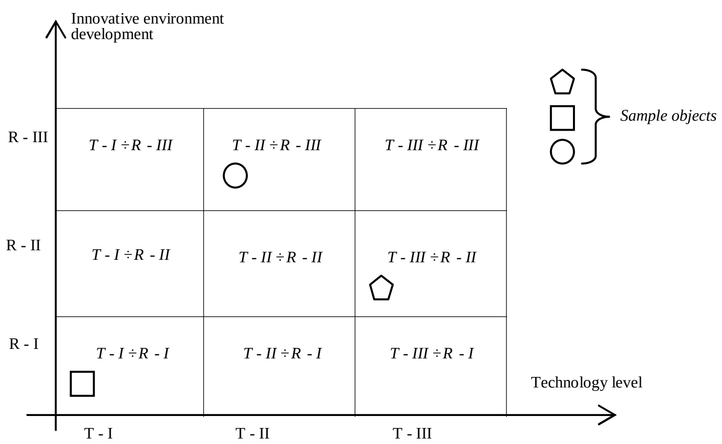

Fig. 1. Map in the form of rank matrix
Source: the authors

Descriptive characteristics of the individual ranks are presented in table 1. These are very general qualitative characteristics, which can be helpful in determining quantitative characteristics and formulating criteria of assigning to particular ranks on the map.

Tab. 1. Descriptive characteristics of development ranks

Innovative environment development	R-III	T-I÷R-III Low technology level High level of innovative environment development	T-II÷R-III Average level of technology High level of innovative environment development	T-III÷R-III High technology level High level of innovative environment development
	R-II	T-I÷R-II Low technology level High level of innovative environment development	T-II÷R-II Average technology level Average level of innovative environment development	T-III÷R-II High technology level Average level of innovative environment development
	R-I	T-I÷R-I Low technology level Low level of innovative environment development	T-II÷R-I Average level of technology Low level of innovative environment development	T-III÷R-I High level of technology Low level of innovative environment development
RANKS		T-I	T-II	T-III
		Technology level		

Source: the authors [3]

Applying the quantitative criteria for assigning the studied organizations to particular ranks requires selecting measurable parameters and defining proper indicators. For that purpose a simple organization model as an object with two input and three output signals was suggested (Fig.2).

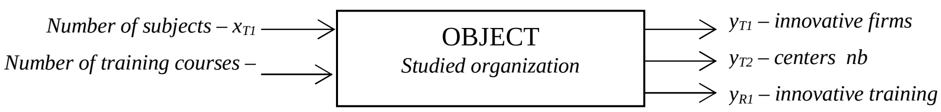

Fig. 2. Organization model
Source: the authors

On the basis of the assumed model two indicators were defined. The technological level indicator w_T, which represents the percentage of innovative technological firms (y_{T1}) with respect to the total number of subjects operating in the centre (x_{T1}) and is calculated in the following way:

$$w_T = \frac{y_{T1}}{x_{T1}} \quad (1)$$

And the development of innovative environment w_R, which represents the percentage of innovative training (y_{R1}) with respect to the total number of training courses (x_{R1}) and is calculated in the following way:

$$w_R = \frac{y_{R1}}{x_{R1}} \tag{2}$$

The values of calculated indicators (w_T , w_R) and the parameter determining the number of scientific and research centres (y_{T2}) assigned to each object investigated allow for placing them on the map considering the assumed assigning criteria. Sample criteria of assigning the relation type are presented in table 2.

Tab. 2. Relation criteria of centre ranking

R-III	$w_R \geq 50\%$ $w_T=0$ and $y_{T2}=0$	$w_R \geq 50\%$ $0<w_T<75\%$ and $y_{T2}=0$	$w_R \geq 50\%$ $w_T \geq 75\%$ and $y_{T2}>0$
R-II	$25\% \leq w_R<50\%$ $w_T=0$ and $y_{1nb}=0$	$25\% \leq w_R<50\%$ $0<w_T<75\%$ and $y_{T2}=0$	$25\% \leq w_R<50\%$ $w_T \geq 75\%$ or $y_{T2}>0$
R-I	$w_R<25\%$ $w_T=0$ and $y_{T2}=0$	$w_R<25\%$ $0<w_T<75\%$ and $y_{T2}=0$	$w_R<25\%$ $w_T \geq 75\%$ or $y_{T2}>0$
	T-I	T-II	T-III

Source: the authors [3]

Relation criteria allow only for assigning the centre investigated to a selected rank on the map without indicating the relation between the centres within the ranks. Another assigning criterion is presented in the paper [9, 10], where the DEA (Data Envelopment Analysis) method was used as a tool of establishing partial order in multidimensional sets [11].

This method of ranking the innovation and entrepreneurship centres is not a typical statistical method. It allows to rank the centres in an individual way on the basis of the activity measurements in two areas, which can be applied in benchmarking procedures. According to the ranking suggested the affiliation to the development rank is determined by the subjective choice of parameters and the way they are calculated, which should be taken into consideration while generalizing the evaluation of resources.

5. Technological parks-research results

Technological Parks constitute an important group in the infrastructure of the innovation systems. The paper [3] presents study results conducted for 15 Technological Parks for the data from the year 2007. The group was composed of five organizationally-advanced parks, conducting a complete range of statutory activities, and ten Parks at the initial stage of their development with a limited range of activities. Development changes dynamics can be observed in the studies of the 15 Parks on the basis of the data obtained from the subsequent years. Table 3 contains a list of Parks for which research was conducted. The Parks were assigned letter codes used for identifying the objects in the further part of the paper.

Tab. 3. Technological parks- objects examined

No.	Technological Park Name	Town	Code
1	Bełchatowsko-Kleszczewski Park Przemysłowo-Technologiczny	Bełchatów	A
2	Gdański Park Naukowo-Technologiczny	Gdańsk	B
3	Pomorski Park Naukowo-Technologiczny	Gdynia	C
4	Park Naukowo-Technologiczny „TECHNOPARK”	Gliwice	D
5	Park Naukowo-Technologiczny	Koszalin	E
6	Krakowski Park Technologiczny	Kraków	F
7	Łódzki Regionalny Park Naukowo-Technologiczny	Łódź	G
8	Płocki Park Przemysłowo-Technologiczny	Płock	H
9	Nickel Technology Park Poznań	Poznań	I
10	Poznański Park Naukowo-Technologiczny	Poznań	J
11	Park Naukowo-Technologiczny Polska - Wschód	Suwałki	K
12	Szczeciński Park Naukowo-Technologiczny	Szczecin	L
13	Tarnowski Park Naukowo-Technologiczny	Tarnów	M
14	Toruński Park Technologiczny	Toruń	N
15	Wrocławski Park Technologiczny	Wrocław	O

The indicators w_T , w_R were calculated on the basis of the data from the years: 2007, 2009, 2010. Their level of development was also determined. The analysis results are presented in table 4. The source data for the study were obtained from the reports of the Association of the Innovation and Entrepreneurship Centres Organizers in Poland and telephone surveys conducted by the authors.

Tab. 4. Objects examined – analysis results

No.	Code	2007					2009					2010				
		w_T	y_{T2}	w_R	T-X	R-X	w_T	y_{T2}	w_R	T-X	R-X	w_T	y_{T2}	w_R	T-X	R-X
1	**A**	0,30	0	0,30	T-II	R-II	0,16	1	0,30	T-III	R-II	0,00	0	0,33	T-I	R-II
2	**B**	0,71	0	0,67	T-II	R-III	0,00	3	0,17	T-III	R-I	0,00	3	0,43	T-III	R-II
3	**C**	0,13	0	0,14	T-II	R-I	0,11	2	0,25	T-III	R-II	0,08	2	0,18	T-III	R-I
4	**D**	1,00	0	0,17	T-III	R-I	0,33	0	0,11	T-II	R-I	0,43	0	0,00	T-II	R-I
5	**E**	0,00	0	0,33	T-I	R-II	0,00	0	0,14	T-I	R-I	0,00	0	0,14	T-I	R-I
6	**F**	0,18	0	0,33	T-II	R-II	0,18	3	0,25	T-III	R-II	0,01	0	0,23	T-II	R-I
7	**G**	0,00	0	0,31	T-I	R-II	0,00	0	0,33	T-I	R-II	0,00	0	0,31	T-I	R-II
8	**H**	0,00	0	0,27	T-I	R-II	0,00	0	0,27	T-I	R-II	0,36	2	0,27	T-III	R-II
9	**I**	0,02	3	0,43	T-III	R-II	0,19	3	0,27	T-III	R-II	0,20	3	0,31	T-III	R-II
10	**J**	0,00	0	0,20	T-I	R-I	0,00	0	0,33	T-I	R-II	0,00	0	0,33	T-I	R-II
11	**K**	0,00	0	0,43	T-I	R-II	0,00	0	0,29	T-I	R-II	0,00	0	0,17	T-I	R-I
12	**L**	0,00	0	0,20	T-I	R-I	0,91	0	0,00	T-III	R-I	0,91	0	0,00	T-III	R-I
13	**M**	0,00	0	0,50	T-I	R-III	0,00	1	0,40	T-III	R-II	0,00	1	0,33	T-III	R-II
14	**N**	0,83	1	0,23	T-III	R-I	0,31	1	0,27	T-III	R-II	0,22	1	0,31	T-III	R-II
15	**O**	0,00	0	0,11	T-I	R-I	0,07	0	0,00	T-II	R-I	0,09	0	0,20	T-II	R-I

Source: the authors

A rank matrix (map) for the objects examined is shown in figure 3. The location of the individual objects on the map in subsequent years (an element in the shape of a cirle-2007, a pentagon-2009, a square-2010).

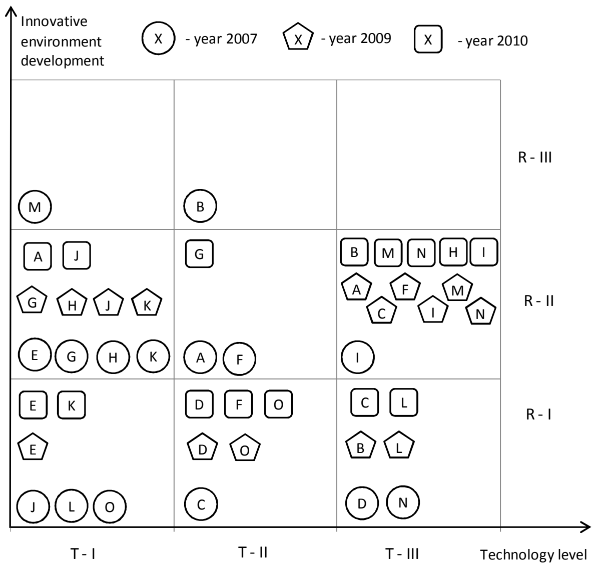

Fig. 3. Rank matrix for technological parks
Source: the authors

Many objects change their location on the map in subsequent years, which is a reflection of changes connected with their structure and principles of functioning. The bar charts (fig.4) show the numbers of objects assigned to individual ranks in subsequent years. It is easy to observe that the largest growth occurred in ranks: T-II÷ R-I and T-III÷R-II.

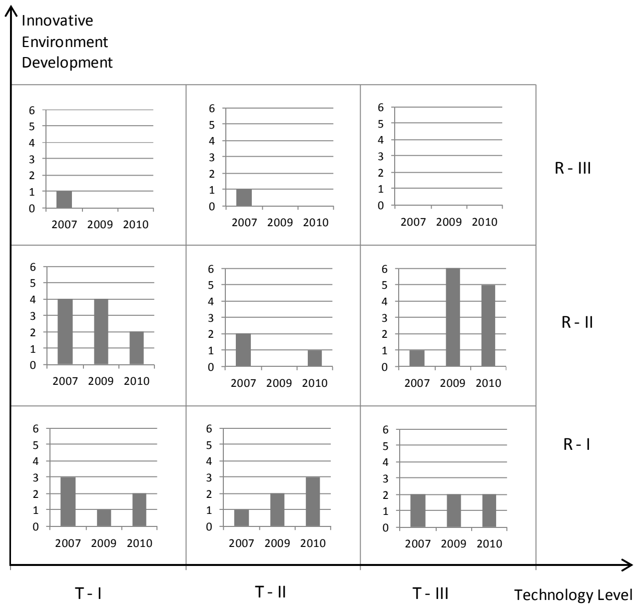

Fig. 4. Location changes on the rank map
Source: the authors

The Dynamics of changes with relation to every of the 15 objects analyzed (technological parks) is shown by arrow graphs in figure 5. The first arrow in every graph represents changes between the years 2007-2009, the second arrow represents the changes between the years 2009-2010.

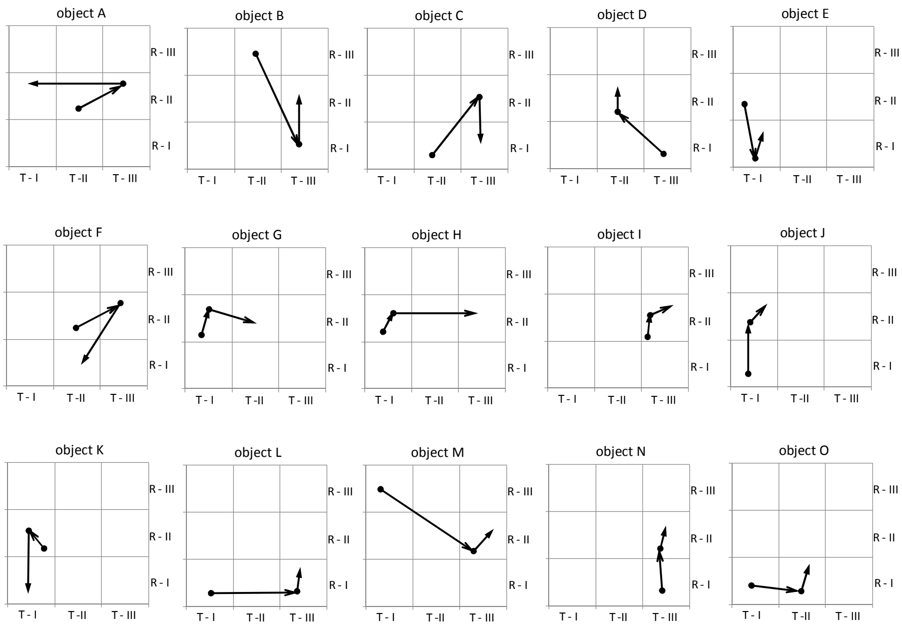

Fig. 5. Changes in the location of objects on the rank map in respective years
Source: the authors

Changes dynamics can be determined by the set of integers ranging from <-2,+2>, assuming that the changes measure is the difference between the phase number for the final (year 2010) and initial (year 2007) position. Positive numbers mean transfer to a higher phase, which is associated with development. Negative numbers indicate transfer to a lower phase. The analysis results showing the dynamics of changes are shown in figure 6. Changes are presented separately for both parameters creating the map (technology level and innovative environment development). Average values were assumed as combined measures for the 15 examined objects. The average growth in technology level is positive and is 0.57 while the innovative environment development is negative with its value -0.14.

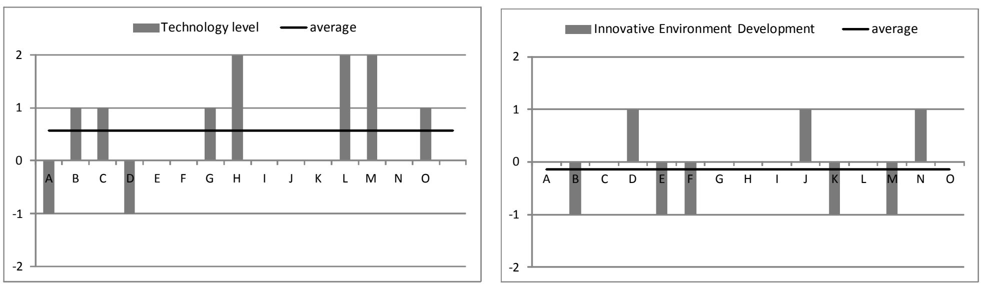

Fig. 6. Dynamics of changes for development ranks
Source: the authors

A positive tendency can be observed. The number of objects with higher level of technology increased, which contributes to economic development. Whereas no oriented changes connected with the development of the innovative environment (very little value of average changes) can be observed. Thus the rank in this area can be considered stable.

6. Conclusions

Creating innovation systems is a new form of economic and innovative activities, generating demand for research and innovations. Fostering entrepreneurship on the border of science and economy is a challenge for Poland and the growing system of support. It is the innovative subjects operating within the sphere of advanced technologies that are the key to enhancing competitiveness, restructuring and modernizing the economy.

Technological and Scientific Parks are an essential element of innovative systems in Poland. Their most important task is to support enterprises in inventing innovative goods and services, making research infrastructure available, and also making contacts easier between entrepreneurs and scientists, administration representatives and investors interested in financial support of their crucial business ideas.

Polish parks owe faster pace of development and a better quality of infrastructure facilities to resources from the European Funds. The construction of new buildings is financed from these resources (e.g. activity 5.3 Operational Programme: Innovative Economy, "Supporting Innovation Centres" and 1.3 Operational Programme: Eastern Poland Development, "Supporting Innovations") as well as providing them with modern equipment needed in generating new products. These resources also allow to operate the entrepreneurship incubators, which support newly started companies at the stage of pre-incubation and incubation.

Present methods of evaluating subjects' activities towards innovations do not satisfy all the needs. Hence the concept of the presented approach to the way of examining and evaluating the infrastructure of innovation systems on the basis of a bi-parametrical model. The measures of key functions performed by the technological parks were assumed as the model parameters. They were defined as technology level and innovative environment development. The assumption of the bi-parametrical model allows for presenting the examined centres as points in the plane, and creating a kind of map as a rank matrix, which illustrates their functional location in a simple way. In a bi-parametrical model one avoids evaluation determined according to the linear order, and while comparing the centres one can account their uniqueness.

Research results of the technological parks activities refer to a short period of time and in order to formulate generalizations they need to be continued. However, positive tendencies indicated in this paper may prove the programme of creating technological parks successful. After the period of creating and fostering the innovative environment, the present technological parks focus their activities on the transfer of technology- at the time of research seven parks were transferred to higher levels of technological development, and only three reached higher levels of innovative environment development.

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