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**Role of technology
entrepreneurship
in the development
of innovativeness
of small and medium-
sized enterprises**

1. Introduction

Technology entrepreneurship is a concept of transforming research and potential of scientific institutions into new products and services, which significantly increases benefits to consumers and results in a faster economy growth in the future. By ensuring effective and synergistic relations where science meets economy (taking into account the wider effect of the so-called business environment), technology entrepreneurship focuses on implementing innovative solutions and ensuring their market success, as well as on using their applications and distributing their effects in the business environment (Flaszewska, Lachiewicz 2013, pp. 14-18). In consequence, it has the potential to become one of the key factors in **building the innovation potential** of modern enterprises. This applies in particular to small and medium companies, which due to their resource shortages possess limited ability to carry out independent research and development activities.

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Taking the above into account, **the aim selected for the article** was to identify

and evaluate the role of technology entrepreneurship in the development of innovativeness of small and medium-sized enterprises. In order to achieve this aim, a survey was performed among a random sample of 300 SME sector companies in the łódzkie province. This research was performed in the implementation of project no. 2015/17/B/HS4/00988, funded by the National Center of Science.

2. Theoretical basis for using the concept of technology entrepreneurship in stimulating innovativeness of SME sector companies

Innovativeness is seen as one of the key factors in achieving success and increasing effectiveness of modern business. It also allows modern companies to build a permanent competitive advantage, mostly through such positive effects as (Cassiman, Golovko, Martínez-Ros 2010, pp. 372-376; Rosenbusch, Brinckmann, Bausch 2011, pp. 441-457): increasing quality and effectiveness, limiting costs, increasing customer loyalty, internationalization of operations of modernizing management processes and methods. A significant role in the development of innovativeness is played by **small and medium enterprises** (SMEs), which are characterized by specific quantitative and qualitative features and which stand in opposition to the category of large enterprises (Lachiewicz, Matejun 2012, pp. 13-22). They are categorized using a uniform definition specified in European Commission Regulation 2004, based on: number of employees (upper limit is 249 employees), revenue and asset size, while remaining independent from other organizations with regards to capital.

When presenting the characteristic features of companies in this sector (Safin 2008, pp. 30-42; Nicolescu 2009, pp. 405-413; Storey, Greene 2010, pp. 30-52) some authors stress their significant innovation potential, justified by such qualitative features as: high level of entrepreneurship and flexibility in action, promptness in taking decisions, close and direct relations with the environment and limited formalization of operations. On the other hand, results of numerous studies (e.g. Kaczmarska-Krawczak 2014, pp. 99-111; Dutta, Lanvin, Wunsch-Vincent 2015) indicate, that the level of innovativeness in SMEs is lower than the level presented by large enterprises, and engagement in innovation and implementing innovative solutions decreases with the size of the company. One of the major weaknesses of small businesses in this regard is a significant shortage of resources, both financial and other than financial (as compared to large enterprises), which limits the scope of operations, level of marketing, research and development, investment activities and, as a result,

the level of innovation (Qian, Marcus, Li 2014, pp. 22-23; Block, Fisch, Hahn, Sandner 2015, pp. 1915-1930).

The **concept of technology entrepreneurship** is an interesting proposition that aims to limit these shortcomings and develop innovativeness of small and medium enterprises. As part of the concept, research and potential of scientific and research and development institutions is transformed (through the engagement of commercial entities and institutions of business environment) into products and services distributed on market principles and providing new values and desired benefits to clients (Garud, Karnøe, 2003, pp. 277-300; Bailetti, 2012, pp. 5-12). The concept is based on such theoretical foundations as: the notions of intellectual entrepreneurship (Kwiatkowski 2000), academic entrepreneurship (Poznańska, 2014, pp. 164-172), issues of transfer and commercialization of technology (Gianiodis 2015, pp. 207-210) and management of knowledge and high-tech enterprises (Kordel 2014, p. 20).

The concept of technology entrepreneurship is of particular benefit to SMEs which have already attained some level of development and are planning on increasing competitiveness and further expansion in the market by introducing products and services based on modern technologies into its offer. However, the shortages in resources mentioned above hinder or prevent them from carrying out their own activities with regards to innovation, which leads to an increase in their engagement in the transfer of knowledge and new technologies from the scientific and technical environment (Flaszewska, Lachiewicz, 2013, pp. 21-22) while using financial and non-financial support from the small business environment (Brown, Mason 2014, pp. 773-784), mostly based on the concept of an organization's positive potential (Kurowska, Matejun, Szymańska 2013, pp. 56-57).

Thus defined scope of operations forming part of the concept of technology entrepreneurship requires a simultaneous and synergistic involvement of the enterprise in 4 basic areas (own study based on: Flaszewska, Lachiewicz, 2013, pp. 14-24; Kordel 2014, pp. 20-25; Chyba 2015, pp. 31-34):

1. Internal company entrepreneurship, closely tied to the concept of intraentrepreneurship in SME sector companies (Gorzelay-Dziadkowiec 2014, pp. 87-97), which should concentrate on identifying and developing market opportunities and commercializing ideas in order to create economical values. Of significant importance is the creation among employees of an attitude of openness to knowledge and new solutions, listening to ideas submitted by employees and implementing them and lowering obstacles hindering proposed changes and creative ideas.

2. **Own technology and innovation potential** concerning the identification and development of required: knowledge, competences and technologies, building the company's own research and development back-office and implementing appropriate procedures and methods of diffusing, storing, codifying and protecting knowledge.
3. **Integration of business and science**, e.g. through organizing teamwork in cooperation with employees of research and development institutions, ensuring that employees have access to required external knowledge and building a network of connections allowing for the exchange of knowledge between the company and its environment.
4. **Market distribution of technological and innovation effects**, through developing an orientation on marketing and marketing abilities connected with it (Lin, 2015, pp. 292-293). This area mostly includes market analysis with a view to identifying the demand for new products and services, searching for information necessary to implement new technologies and obtaining feedback from clients concerning the market offer introduced by the company.

Involvement in developing technology entrepreneurship may be a source of numerous benefits to SMEs, allowing them to create an efficient and permanent competitive advantage. Among the most important of such benefits are those concerning the market, organization and operating efficiency (Motyka 2015, pp. 87-95). **Technological and innovation benefits** are also an important group; these include, among others, the integration and concentration of the potential of the company and its environment on searching for innovations, extending the scope of operations, improvement of available internal and external knowledge and using it in practice, increasing chances for achieving market success by introducing innovations and modernizing the company's offer, shortening the time required to manufacture products and avoiding technological mistakes and preventing their occurrence.

The theoretical basis for the concept of technology entrepreneurship therefore indicates that it can be widely used to stimulate the development of innovativeness among SMEs. The complex character of this concept allows for a stimulating effect on all stages of the process of managing innovations, the aim of which (in a systemic approach) is to concentrate resources, competences and efforts of the enterprise on achieving goals that concern innovation J. Baruk (2010, pp. 57-59; 2013, p. 12) states that this process comprises the following stages: generating ideas on how to solve a given problem, evaluating the ideas thus generated based on specific criteria and choosing the best variant, generating concepts for solving the problem and their evaluation, turning

the selected concept into a project, creating the innovation and ensuring its market success through integrated activities in the field of market research and distribution and sales. The stimulating effect of concepts of technology entrepreneurship manifests itself by e.g. access to external resources (mostly knowledge and skills), which allow for valuable, creative ideas and concepts to be submitted, performance abilities to be extended both thanks to the development of the enterprise's technological potential and an increase in the ability of its organization to learn and anticipate market trends. Innovation management models (more information in: Trott 2008, pp. 20-29) also point out the necessity of intensifying the interactions between a company and its environment, as well as the need to expand the enterprise's boundaries (Chesbrough 2003, pp. 35-41), which also constitute important areas that form part of the concept at hand.

As a result of involvement in technology entrepreneurship, an increase of implementation of various innovations in SMEs should be expected; such innovations include (Oslo Manual 2005, pp. 47-52; Sagar, van der Zwaan 2006, pp. 2601-2608; Damanpour, Aravind 2012, pp. 506-508.):

1. Product innovations - introduction of a good or service offered by the company that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and/or materials, incorporated software, user friendliness or other functional characteristics.
2. Process (including marketing process) innovations - the implementation of a new or significantly improved production, marketing or delivery method. This includes significant changes in techniques, equipment, IT, software and also includes marketing solutions such as product placement, product promotion or pricing.
3. Organization and management innovations - the implementation of a new organizational or management concepts and methods in the firm's business practices, workplace organisation or external relations of the company.
4. Technology innovations - the implementation of new (or improved) technologies that are developed and brought into widespread use. This includes solutions in research, development, demonstration, and deployment of various technologies.

As a result of the above considerations, we can **adopt a research hypothesis** that the development of technology entrepreneurship in SME sector companies has a significant and positive effect on the level of innovativeness of these entities. The empirical verification of this assumption is presented below.

3. Research methodology and characteristic features of analyzed enterprises

In order to achieve the aim of this paper and to verify the research hypothesis, empirical research was performed using the nomothetic approach (Niemczyk 2015, pp. 22-23) and **the survey method** on a random sample of 300 companies from the SME sector based in province of łódzkie. The adopted research technique was based on a printed survey handed directly to respondents. The research tool was an original survey that included 40 questions divided into 4 sections based on their subject matter (for more information on the methodology of research see: Matejun 2013, pp. 103-114). The size of examined enterprises was determined based on the terms of the uniform European definition of MSE sector companies, taking into account their total employment in terms of full-time equivalents. Based on declarations made by respondents, two separate classes of analyzed entities were identified:

- 201 (67%) small companies with an average yearly employment in the range of 10-49 persons,
- 99 (33%) medium companies with an employment in the range of 50-249 employees.

The survey involved mostly companies functioning as natural persons conducting business operations (59%) and limited liability companies (22%). Most of them are stable entities, who have existed for a period exceeding 10 years (58%), and who operate in technologically conservative industries (82%), mostly in the services and manufacturing sectors in local markets. A detailed characteristic of the surveyed companies can be found in table 1.

Table 1. Characteristics of the surveyed small and medium-sized enterprises

Legal form:	N	%	Level of technological development:	N	%
individual company	179	59%	Traditional technologies	247	82%
private partnership	34	11%	Advanced technologies	53	18%
general partnership	5	2%			
limited liability company	66	22%	Sector:	N	%
joint stock company	8	3%	services	150	50%
other forms	8	3%	manufacturing	146	49%

Company longevity:		N	%	Scope of operations:	
1 year and less	1	0,5%	commerce	4	1%
between 1 and 3 years	4	1,5%	local	105	35%
between 3 and 5 years	30	10%	regional	79	27%
between 5 and 10 years	90	30%	domestic	67	22%
more than 10 years	175	58%	international	49	16%

Source: own study based on survey results

Survey respondents included owners (66%) or managers (34%) of the surveyed entities. They were mostly males (59%), 40 or more years old (64%), mostly graduates of higher education institutions (55%) with degrees in technical (58%) or economic (31%) fields.

Statistical analysis of obtained results was performed using IBM SPSS Statistics software. The following functions were used: (1) analysis of sample size and arithmetic mean as measures of location, (2) Pearson's correlation coefficient (and significance test) r_{xy} as a measure of interdependence of phenomena, and (3) analysis of linear regression to evaluate the effect of the independent variable on the dependent variable. To interpret the dynamics of interdependence of phenomena, an approach based on a proposal made by J. Cohen (1992, pp. 155-159), was adopted, adjusted to fit the specific nature of behavioral research, the use of which is recommended to evaluate social opinions in management science (Pell, Fogelman 2007, p. 347). In light of the above, the following interdependence scores were taken as cutoff scores of the linear correlation coefficient: 0.1 - weak; 0.3 - medium; 0.5 - strong, 0.7 - very strong.

4. Relations between technology entrepreneurship and innovation in the practical functioning of small business

In the first part of the research, the extent of involvement of surveyed enterprises in the **development of technology entrepreneurship** was evaluated. A synthetic indicator, operationalized based on the considerations presented in the theoretical part of this paper, was used for this purpose. With regards to each constituent area of technology entrepreneurship, specific substantive

coefficients were selected that could be directly observed by survey respondents in their business operations and evaluated. With regards to technology entrepreneurship, the following areas were analyzed:

- creating an organizational culture based on knowledge,
- creating an attitude of openness to knowledge and new solutions among employees,
- listening to ideas submitted by employees and implementing them,
- lowering obstacles preventing the implementation of changes and ideas coming from outside the company.

With regards to the area of integration of science and business, focus was placed on organizing teamwork in cooperation with employees of research and development institutions, ensuring that employees can access knowledge (project databases, experts) required to perform the tasks they are entrusted with and building networks allowing for the exchange of knowledge between employees, scientific institutions and organizations that support the transfer of technologies. With regards to effects of technology and innovation, focus was placed on such aspects as: analyzing the environment with regards to demand for products and services which the company could supply, analyzing entities present in the market (clients, suppliers, competitors, cooperants etc.) in order to obtain information required to implement new technologies and receive feedback from clients concerning the implemented products/services. The area of internal technological and innovation potential was operationalized in the form of the following indicators:

- identification of the needs of the company with regards to knowledge, competence, technology,
- determining the current state of knowledge in the enterprise and gaps in intellectual resources,
- building the company's own research back office,
- implementing procedures of document tasks and projects that are underway at a given moment,
- promoting and rewarding knowledge sharing,
- determining the manner of storing, codifying, protecting knowledge and criteria of providing access to such knowledge.

Each of the indicators was evaluated using R. Likert's scale from 1 (does not apply to our company at all) to 5 (completely applies to our company). To evaluate the accuracy of the scale used, Cronbach's alpha coefficient was applied, which allows for the evaluation of the degree of conformity between several indicators of a specified variable (Hair et al. 2006, p. 137). The calculated result

was $\alpha_{Cr.} = 0,868$, which indicates a high degree of accuracy of the scale (Sarstedt, Mooi 2014, p. 256). As a result, it was possible to determine the level of development of technological entrepreneurship (as well as its constituent areas) as an arithmetical mean of its separate indicators. Results of this evaluation can be found in table 2.

Table 2. Level of development of technology entrepreneurship in selected SME sector companies

Evaluated area	Total in sample	Small companies	Medium companies
Total level of development of technology entrepreneurship, including the following areas:	2.50	2.59	2.32
• internal entrepreneurship,	2.91	3.05	2.61
• internal technological and innovation potential,	2.47	2.54	2.33
• integration of business and science,	1.79	1.87	1.63
• distribution of effects of technology and innovation.	2.72	2.78	2.58

Source: own study based on survey results

The results indicate an average level of development of technology entrepreneurship within the surveyed sample. The entrepreneurship is stimulated mostly through activities performed in the area of internal entrepreneurship and is aimed mostly at distributing technological and innovation effects on the market arena. Actions aimed at integrating business and scientific environments constitute a significant damper of this development and have been evaluated at a low level.

In the next part of the study, the **level of innovation of surveyed SME sector companies** was determined. The number of innovations implemented in the previous 5 years was used as a yardstick. The survey questionnaire allowed respondents to choose between 4 basic types of innovation: concerning products, processes, organization and management and technology. Each of these types was briefly described to help the respondents make a choice, increase the accuracy of responses and allow for comparability of results. In each case respondents gave a declared number of innovations implemented. Results indicate a medium level of innovation among the surveyed enterprises. Although 104 enterprises (35%) declared that at least 1 innovation had been implemented during the previous

5 years, 32 companies (11%) indicated that only 1 innovation concerning products was implemented. The number of companies that declared the implementation of individual types of innovations can be found in table 3.

Table 3. Scope of implementing innovation in selected SME sector companies

Area of evaluation	Total		Small companies		Medium companies	
	N	%	N	%	N	%
Implementation of innovations in the previous 5 years, including:	104	35%	67	33%	37	37%
• innovations in products	91	30%	61	30%	30	30%
• innovations in processes	36	12%	22	11%	14	14%
• innovations in organization and management	25	8%	12	6%	13	13%
• innovations in technology	21	7%	12	6%	9	9%
No innovations	196	65%	134	67%	62	63%

Source: own study based on survey results

In the last part of the study, an analysis of the relations **between the development of technology entrepreneurship and innovation level** of the surveyed enterprises was performed. Results indicate that these variables are statistically significant, positively and strongly correlated both within the entire sample, $r_{xy} (N = 300) = 0.53, p < 0.01$, as well as within individual classes of enterprise sizes: small companies, $r_{xy} (N = 201) = 0.53, p < 0.01$ and medium companies, $r_{xy} (N = 99) = 0.59, p < 0.01$. In order to determine the impact of technology entrepreneurship on the development of innovation of surveyed companies, a simple linear regression analysis was performed using the input method. Results indicate that the level of technology entrepreneurship as a statistically significant independent variable ($F = 114.64, p < 0.01$) explains the development of innovation in surveyed enterprises measured by the number of innovations implemented in the previous 5 years. The general regression equation is expressed by the following formula: y (innovation level) = $2.07 x$ (development of technology entrepreneurship) - 4.16.

The above indicates that the full engagement of surveyed companies in developing the concept of innovation entrepreneurship allows for the increase

in the number of implemented innovations by 452% in a 5-year period, from 2 to ca. 12 innovations. The level of declaration of the dependent variable by the predictor amounts to $R^2 = 0.28$. A similar diversity was obtained within separate classes of surveyed enterprises based on their size. Engagement in technology entrepreneurship in a statistically significant manner explains the development of innovation both with regards to small companies, ($F = 77.46$, $p < 0.01$), as well as medium ones ($F = 50.42$, $p < 0.01$). However, when it comes to medium companies, the level of declaration of variability of innovation through the use of the concept at hand is higher - $R^2 = 0.34$ - than in the case of small companies - $R^2 = 0.28$. Despite the rather low result, taking into account the complexity and multidimensional nature of the theoretical constructs placed under analysis the alignment of the proposed models may be deemed as satisfactory. The results obtained **provide therefore a positive verification of the research hypothesis** formulated in the theoretical section of the paper. They also constitute an argument for strengthening the concept of technology entrepreneurship in order to stimulate the innovativeness level of SMEs.

The last part of the study evaluated the effect of development of technology entrepreneurship on the scope of implementation of individual types of innovation among surveyed companies. Table 4 contains results of this evaluation, which include the level of interdependence between variables analyzed using Pearson's coefficient and significance test r_{xy} , as well as synthetic results of a single factor analysis of linear regression. Results of this evaluation indicate that the level of development of technology entrepreneurship is determined mostly by the **scope of implementing innovations concerning products**, accounting in a statistically significant manner for ca. 30% of its variability. This effect is more significant for medium than for small companies.

Table 4. Relations between the level of development of technology entrepreneurship and the scope of implementing individual types of innovation in surveyed companies

Field of evaluation	Total		Small companies		Medium companies	
	r_{xy} (N=300)	F R ²	r_{xy} (N=201)	F R ²	r_{xy} (N=99)	F R ²
Implementing innovations in total, including:	0.53**	114.64** 0.28	0.53**	77.46** 0.28	0.59**	50.42** 0.34
• innovations in products	0.53**	197.41** 0.28	0.51**	70.92** 0.26	0.60**	53.38** 0.36

• innovations in processes	0.33**	35.91** 0.11	0.34**	26.50** 0.12	0.37**	15.08** 0.14
• innovations in organization and management	0.20**	12.43** 0.04	0.20**	8.09* 0.04	0.27**	7.45 0.07
• innovations in technology	0.36**	42.84** 0.13	0.30**	19.22** 0.09	0.46**	25.28** 0.21

* $p < 0.05$; ** $p < 0.01$. rxy: significance test of Pearson's linear correlation coefficient. F: single factor linear regression analysis. Dependent variable: level of innovation measured by the number of innovations implemented in the previous 5 years. Independent variable: level of development of technology entrepreneurship.

Source: own study based on survey results

Use of the described concept has also a statistically significant effect, although to a much lower degree, on the scope of implementation of innovations in processes and technologies. The impact of technology entrepreneurship development on this last type of innovation can be seen mostly in medium companies, where it accounts for over 20% of variability in the level of implementation of innovation in technologies. The scope of implementation of innovations in organization and management to a very small (negligibly small) degree depends on the scope of development of the concept of technology entrepreneurship, which most of all applies to medium companies.

5. Conclusions

The concept of technology entrepreneurship constitutes an interesting proposition for enterprises whose aim is to increase its level of innovativeness through a synergistic use of interactions between the internal capabilities of the company and the potential of the environment, represented by research and development institutions and entities from the high-tech sphere. In its underlying assumptions, the concept takes into account the advantages enjoyed by MSE sector companies, such as a high level of entrepreneurship and a market opportunity-oriented approach. However, it also stresses the need to ensure appropriate solutions concerning the distribution of technological and innovation effects from the scientific area to the sphere of business practice. The above is confirmed by results of a survey conducted using a sample of 300 small and medium enterprises based in the vicinity of the city of Łódź. Based on these results, the following **conclusions** can be formulated:

- the surveyed enterprises believe that their technology entrepreneurship is developed at a medium level; a too-low level of interactions with the research and development environment constitutes a significant inhibitor of technology entrepreneurship,
- involvement in the sphere of technology entrepreneurship has a significant effect on the level of innovativeness of surveyed enterprises, mostly stimulating the scope of implementation of innovations in products and – in medium-sized companies – in technology.

Hopefully the results presented in this paper will be of interest to owners and managers of SMEs interested in increasing their competitiveness through expanding the scope of implemented innovations. To this end, they should use the concept of technology entrepreneurship, principally through developing their relations with the scientific sphere and technical and technological environment. Its use may be of particular benefit to medium-sized companies, where it might contribute to the implementation of various innovative solutions resulting in a permanent market advantage.

When implementing the proposed solutions, attention must be given to the **limitations of the presented research**. These include relatively small sample size – the study conducted on a sample of 300 small and medium-sized cannot be representative and does not permit generalisations. These include also a high level of subjectivity in the opinions of respondents and the operationalization of the applied theoretical constructs only based on selected indicators, which might limit the accuracy of conclusions made on their basis. Further research into this issue is surely required. Plans for the future include the use of triangulation of quantitative and qualitative results, expanding the subject matter of the survey to enterprises from other countries of the European Union and paying particular attention to the effect of taking advantage of opportunities on the increase in innovativeness of SME sector companies.

Summary

Role of technology entrepreneurship in the development of innovativeness of small and medium-sized enterprises

Technology entrepreneurship is an interesting concept for transforming the potential of the scientific and research and development fields (including a wider impact of the so-called business environment sphere) into innovative products and services. In consequence, it might become a key factor in building the innovation potential of modern enterprises, especially SME

sector enterprises, which due to their resource shortages have limited ability to carry out independent research and development operations. Taking the above into account, the aim of the article is to identify and evaluate the role of entrepreneurship in the development of innovativeness of SMEs. To achieve this aim, a survey was conducted on a sample of 300 SMEs based in the Łódzkie province.

Keywords: *technology entrepreneurship, innovation management, small and medium-sized enterprises.*

Streszczenie

Rola przedsiębiorczości technologicznej w rozwoju innowacyjności małych i średnich przedsiębiorstw

Przedsiębiorczość technologiczna stanowi interesującą koncepcję przekształcania potencjału sfery nauki oraz badań i rozwoju (z uwzględnieniem szerszego oddziaływania tzw. sfery otoczenia biznesu) w innowacyjne towary i usługi. W konsekwencji stać się może jednym z kluczowych czynników budowania potencjału innowacyjnego współczesnych przedsiębiorstw, co dotyczy szczególnie firm sektora MSP, które ze względu na swoje niedobory zasobowe mają ograniczone możliwości prowadzenia samodzielnej działalności badawczo-rozwojowej. Biorąc to pod uwagę, jako cel artykułu wyznaczono identyfikację i ocenę roli przedsiębiorczości w rozwoju innowacyjności małych i średnich przedsiębiorstw. Realizacji celu pracy poświęcono badania ankietowe przeprowadzone na próbie 300 firm sektora MSP z regionu łódzkiego.

Słowa

kluczowe: *przedsiębiorczość technologiczna, zarządzanie innowacjami, małe i średnie przedsiębiorstwa.*

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