Technological opportunities and innovation performance: evidence from Polish manufacturing firms

Tomasz Kijek^a *, University of Life Sciences in Lublin, Akademicka 13, Lublin 20-950, Poland

Elżbieta Skrzypek^b, Maria Curie Skłodowska University, Plac Marii Curie-Skłodowskiej 5, Lublin 20-031, Poland

Suggested Citation:

Kijek, T. & Skrzypek, E. (2017). Technological opportunities and innovation performance: evidence from Polish manufacturing firms. *New Trends and Issues Proceedings on Humanities and Social Sciences*. [Online]. 04, pp 69-76. Available from: www.prosoc.eu

Selection and peer review under responsibility of Prof. Dr. Cetin Bektas, Gaziosmanpasa University, Turkey.

©2017 SciencePark Research, Organization & Counseling. All rights reserved.

Abstract

Technological opportunity is a concept that is attracting attention from scholars and practitioners in the fields of economics and the management of innovation. In general, technological opportunities refer to the contribution of external knowledge to the innovation activities of firms in a given industry. Although the role of external knowledge has been discussed in detail in the open innovation literature, there is still a challenge: how to operationalize technological opportunities and measure their impact on firms' innovation performance. In order to reduce this gap in the literature, our study aims at analysing the effects of technological opportunities on the output of the innovation process. Our empirical research is based on micro-data from the Polish Community Innovation Survey. The sample consists of 1979 manufacturing firms. We use the linear regression to estimate the relationship in which the share of innovative product sale is a function of a set of technological opportunity variables. These variables refer to two distinct measures of technological opportunities, i.e. the contribution of external knowledge to innovation activity and the propensity to collaboration on innovation. Our results show that inter-firm differences in technological opportunities explain inter-firm variation in innovation outcome. Moreover, we do not find any moderating impact from the absorptive capacity on the relationship between technological opportunities and innovation performance.

Keywords: technological opportunities, external knowledge, innovation, absorptive capacity.

* ADDRESS FOR CORRESPONDENCE: **Tomasz, Kijek**, University of Life Sciences in Lublin, Akademicka 13, Lublin 20-950, Poland

E-mail address: tomasz.kijek@up.lublin.pl / Tel.: +48-502-309-001

1. Introduction

The concept of technological opportunities (TO) has been a subject of intense research in the field of industrial organizations for the last thirty years. Many authors (e.g. Becker & Peters, 2000; Klevorick, Levin, Nelson & Winter, 1995; Levin, Cohen & Mowery, 1985; Scherer, 1965) have tried to find how the stock of scientific and technological knowledge grows and how this growth contributes to a firm's innovation process in different institutional and sectorial settings. Unfortunately, many theoretical papers and empirical studies do not give simple answers to these questions. The main problem with the concept of technological opportunities is that it is not precisely defined. This leads to difficulties in using appropriate measures of technological opportunities and in modeling their impact on a firm's innovation performance. In order to overcome these limitations this paper tries to combine the two distinct measures of technological opportunities and incorporates them into the framework of the knowledge production function.

The aim of the article has formed its structure. In the first part of the paper, there is a concise review of literature on technological opportunities presenting the main theories and models of technological opportunities. This culminates in the formulation of research questions. The next section presents the methods and data used in the study. Our results concerning how technological opportunities affect firms' innovation performance are described in section 3. The final section offers concluding remarks and provides possible directions for future research.

2. Literature review and research questions

The origins of the concept of technological opportunity can be found in the neoclassical theory of production. In production theory, a firm decides how to produce a desired output (Varian, 1992). The firm's choice is restricted to feasible techniques (technology), which encompass all combinations of inputs employed in the production process. According to this approach, the possibility of the extension of the production technique set reflects technological opportunity. By analogy, we may compare the role of technological opportunities in manufacturing decisions to the role of natural resources in sustainable development (Kijek & Kasztelan, 2013; Kasztelan, 2010; Kasztelan, 2013). Although the neoclassical theory of production makes the concept of technological opportunity easily interpretable, it does not explain how feasible technology can be extended and, consequently, why some firms have a broader set of production techniques than others. To overcome these limitations, some early theoretical models (e.g. Nordhause, 1969) treat technological opportunity as the elasticity of innovation output (i.e. invention) with respect to R&D investments. Related empirical papers (e.g. Pakes & Schankerman, 1984) try to show that the transformation of innovation input into innovation output is easier (less costly) in some industries than in others, due to differences in scientific and technological knowledge bases. As suggested by Rosenberg (1974), the cost of science-based invention declines as the stock of scientific knowledge grows. For example, the increase in knowledge on the human genome enables the faster (less costly) introduction of new techniques of genome sequencing or typing.

There are many empirical studies that use Scherer's (1965) proposition to classify industries on the basis of scientific or technological field and then employ these classifications in regressions describing the innovation process (Becker & Peters, 2000; Hall, Mairesse & Mohnen, 2010). However, the results of these studies are equivocal, which may result from the fact that industry dummy variables cover more factors (e.g. demand conditions) than technological opportunities. Moreover, technological opportunities in other industries may be sources of technological innovation in a given industry. Striking examples are general purpose technologies (GPT) such as steam, electricity, and information technology, which make the introduction of new products or processes easier in many industries (Jovanovic & Rousseau, 2005).

A more comprehensive approach to measure technological opportunity was proposed by Klevorick et al. (1995). They identified several sources of technological knowledge that reflect an industry's technological opportunities. The sources fall into two groups. The first relates to sources within an industrial chain, i.e. suppliers of materials and production/research equipment, and users (clients). The second is located outside of the industry structure and consists of such sources as universities, government labs and agencies, professional or technical societies, and independent inventors. Moreover, the authors employed the identified proxies of technological opportunities to calculate simple correlations between opportunities and innovation performance. The results indicate that there are some interesting differences in the contribution of particular knowledge sources to product and process innovations.

The approach proposed by Klevorick et al. (1995) has been widely adopted by other researchers at the firm level. For example, Becker and Peters (2000) analyze the effects of technological opportunities on the innovation performance of firms in German manufacturing industry. They postulate the measurement of technological opportunities in two dimensions. The first dimension relates to the importance of different sources of knowledge for a firm's innovation process. The second pertains to a firm's decisions concerning cooperation on innovation. Cooperation is regarded by the authors as the most systematic form of knowledge/technology transfer. The use of both dimensions in exploring the link between technological opportunities and innovation performance is in line with the distinction between spillovers and technology transfer. According to Hall et al. (2010), the former represents the unintended transfer of knowledge. In turn, the latter occurs when an innovator sells the technology or intentionally transfers it to another agent (e.g. a subsidiary or partner).

Another compelling issue in the modeling of technological opportunity in the innovation process is the ability of a firm to absorb and exploit external knowledge. As suggested by Cohen and Levinthal (1990), the absorptive capacity of a firm is a critical component of innovative performance. In other words, the transference of technological knowledge is often difficult, due to its tacit nature and, for this reason; it requires the technology receiver to have efficient knowledge stock and experience. Although some studies confirm the moderating effect of in-house knowledge on the link between technological opportunities and innovation output (Becker and Peters, 2000; Nelson and Wolff, 1997), there are also studies that provide opposing results. For example, Oltra & Flor (2003) find that in-house R&D does not affect the link between co-operation with firms and research centers and innovation outcomes.

Based on the considerations in this section with regard to the impact of technological opportunities on a firm's innovation performance, it is possible to formulate the following research questions:

- How do different sources of external knowledge affect a firm's share of sale from innovative products?
- Does the propensity for cooperation on innovation have an impact on a firm's innovation performance?
- Does absorptive capacity enable a firm to exploit external knowledge more efficiently?

3. Data and methods

This study uses micro-data from the survey of innovation activities of Polish manufacturing enterprises conducted by the Polish Statistical Office in the years 2010–2012. The questionnaire used in this survey was harmonized with the Community Innovation Survey (CIS) methodology. Enterprises with more than nine employees participated in the research. The enterprises were selected on the basis of the Polish Classification of Activities, which closely corresponds to the statistical classification of economic activities in the European Community (NACE Rev. 2). The initial sample of innovation active firms used in this analysis consisted of 2060 enterprises that introduced product innovation in

2010–2012. We decided to exclude from our dataset those firms that declared either a 0% or 100% share of turnover due to innovative products in 2012. Finally, the data set includes 1979 firms.

In order to find answers to the research questions, we decided to use a linear regression model, where the general specification is as follows:

$$y_i = x_i'\beta + \epsilon_i \tag{1}$$

where: y_i is the endogenous variable, x_i is the row vector of the explanatory variables, β is the vector of the parameters, ϵ_i is the error term.

Since the technological opportunities of the firms in our data-set are represented with the help of 12 variables referring to the use of different external knowledge sources, i.e. suppliers, clients (institutional and private), competitors, universities, research institutes (foreign and domestic), consultants/commercial labs, conferences, journals and professional associations, we employed a principal component analysis (PCA) to reduce the dimensionality of the observed set of variables. PCA is a statistical technique used for data reduction while keeping as much of the original variance as possible. In this technique, the eigen or spectral decomposition of the covariance or correlation matrix of the variables leads to the extraction of a set of principal components (uncorrelated linear combinations of the variables) (Jolliffe, 2002). The leading principal components contain most of the variance. Formally, the PCA specification is as follows:

$$F_i = \lambda_{i1}Z_1 + \lambda_{i2}Z_2 + \dots + \lambda_{in}Z_n \quad j = 1, 2, 3, \dots, n \tag{2}$$

where: Z_i – standardized variable, F_i – principal component and λ_{ii} – factor loadings.

Table 1 provides a description of the variables used in our model. It also contains information on the measurement of variables and their coding.

Table 1. List of Variables and Description		
Variable	Description	Measurement
Innovation performance		
INNTURN	Share of sales from innovative products over total turnover	Metric (ln)
Technological opportunities		
COOP	Cooperation on innovation with other enterprises or institutions	Dummy (0/1)
K_S_COC	Competitors and clients (institutional and private) as knowledge sources for innovation	Scores
K_S_SUP	Suppliers as knowledge source for innovation	Scores
K_S_INST	Universities, units of Polish Academy of Science, research institutes (foreign and domestic) and consultants/commercial labs as knowledge sources for innovation	Scores
K_S_OTHER	Conferences, journals and professional associations as knowledge sources for innovation	Scores
Absorptive capacity		
ABS_CAP	In-house capabilities as knowledge sources for innovation	Interval (1-4)
1 – not used; 4-high		

In order to test whether the absorptive capacity has moderating effect on the relation between technological opportunities and innovation outcome we introduced to our regression interaction terms between the technological opportunities related variables and the proxy for absorptive

capacities. According to the literature review, we expect that the sign of the coefficients of the interaction terms will be positive.

4. Results and discussion

Table 2 presents descriptive statistics of the variables. According to the results, cooperation on innovation is undertaken by 46% firms. It is worth noting that Polish manufacturing firms indicate, on average, a relatively high level of use of internal knowledge and low level of use of external knowledge sources. The most important knowledge sources in innovation activity are suppliers, conferences, journals and clients. On the other hand, the least important knowledge sources appear to be foreign research institutes, units of the Polish Academy of Sciences and universities. This seems to be an unfavorable situation, since university research is regarded as the most effective stimulator of R&D in industry (Rosenberg & Nelson, 1994). In the same vein, Floricel and Miller (2003) show that transforming academic research into products is a distinct pattern of innovation in the “new” economy.

Table 2. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
INNTURN	2,017	1,767	-6,280	4,605
COOP	0,457	0,498	0	1
K_S_COC	0	1,791	-1,970	7,194
K_S_SUP	0	1,056	-2,350	2,554
K_S_INST	0	1,791	-1,970	7,194
K_S_OTHER	0	1,418	-2,688	3,726
ABS_CAP	3,256	1,056	1	4

Note: Data have been provided by the Statistical Office in Szczecin. The Statistical Office in Szczecin is not responsible for any conclusions in this publication.

Table 3 contains the results of the regression estimation. In order to identify a set of explanatory variables which have considerable predictive capability, the backward elimination procedure was employed. As expected, cooperation on innovation has a positive impact on innovation performance (model 1 and model 2). Similar results are reported by other authors (Becker & Peters, 2000). As such, this finding has both managerial and innovation policy implications. Firstly, the managers who are responsible for innovation processes in firms should seek possibilities of cooperation with other firms and institutions which strengthens their knowledge base and the chance for success in innovation projects. Secondly, policy makers ought to assign particular attention to supporting networks of cooperation among heterogeneous economic agents in the innovation process.

Table 3. Innovation Output Effect of Technological Opportunities

Variable	Model 1	Model 2	Model 3
COOP	0,144* (0,080)	0,143* (0,081)	
K_S_COC	0,078*** (0,029)		0,076*** (0,029)
K_S_SUP	X		X
K_S_INST	X		X
K_S_OTHER	X		X

ABS_CAP		0,074*	0,068*
		(0,041)	(0,041)
ABS_CAP*COOP		X	
ABS_CAP*K_S_COC			X
Number of observations	1979	1979	1979
R²	0,01	0,01	0,01
F	5,92***	3,90**	5,68***

Notes: * significant at the 0.1 level, significant at the 0,05 level, *** significant at the 0.01 level, x-eliminated variable.

As regards external knowledge sources, we find that institutional, supplier and other sources of knowledge have an insignificant impact on innovation performance. Interpreting this result we have to realize that the impact of the mentioned sources of knowledge on innovation output may be indirect via different innovation activities. It is worth noting that knowledge from competitors and clients positively affects a firm’s intensity of innovative product sales. This seems understandable, if we consider the positive effects of knowledge diffusion and the active involvement of clients into the new product development process. It is reasonable to expect that the pool of knowledge created by firms in a given sector (market) may be useful for other innovators in the same field (Kijek, 2013). However, access to this stock of knowledge depends on knowledge appropriability conditions. Moreover, many empirical studies prove the beneficial effects of gathering information from clients and applying such information to develop products that meet clients’ requirements (e.g. Carbonell, Rodrigues-Escudero & Pujari, 2009; Smets, Langerak & Rijdsdijk, 2013). Cu and Wui (2015) distinguish three forms of client involvement in new product development – the NPD process. The most common option for firms is client involvement as an information/knowledge source. This form of involvement allows firms to gather information on clients’ needs and combine such information with technology to develop product solutions.

From the viewpoint of absorptive capacity, we may notice that higher use/availability of internal knowledge leads to an increase in the percentage of sales of new products (model 2 and model 3). However, the moderating effect of absorptive capacity is not significant when we consider the joint (interaction) effects of the internal knowledge use variable and the cooperation variable (model 2) and the internal knowledge use variable and the use of external knowledge from clients and competitors (model 3). This finding may be explained by the complexity of the moderating effect of absorptive capacity. As suggested by Oltra and Flor (2003), there exist different types of absorption capacity for different types of external knowledge.

5. Conclusion

This paper tries to contribute to the literature on technological opportunities and their impact on innovation performance. We find that cooperation on innovation and use of external knowledge from clients and competitors positively affect the share of sales from innovative products. It also appears that the use of internal knowledge has a positive impact on innovation output. These findings provide managers and policy makers with straightforward recommendations to cooperate on innovation and use external knowledge in the innovation process. It may lead to firms’ performance improvement (Budzynska, 2014).

However, we cannot confirm the moderating effect of absorptive capacity on the link between technological opportunities and innovation performance. As such, future research should consider other proxies for the absorptive capacities which would shed new light on the analyzed relationships. Moreover, there is a need to distinguish between product innovation and process innovation, since we

may expect that different types of absorptive capacities may be needed for different types of innovation.

Acknowledgements

The project was financed by Polish National Science Centre on the basis of decision number DEC 2013/09/D/HS4/01139.

References

- Becker, W. & Peters, J. (2000). Technological opportunities, absorptive capacities and innovation. *Paper presented at The Eighth International Joseph A. Schumpeter Society Conference, Manchester*. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.196.3245&rep=rep1&type=pdf>.
- Budzynska, K. (2014). Impact outsourcing of competitiveness of enterprise (in Polish). *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*, 16 (5), 29-34.
- Budzynska, K. (2014). Creating value added of a business through an off -shoring activities (in Polish). *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, 804, 555-564.
- Carbonell, P., Rodriguez-Escudero, A. I. & Pujari, D. (2009). Customer involvement in new service development: An examination of antecedents and outcomes. *Journal of Product Innovation Management*, 26, 536–550.
- Cohen, W. M. (2010). Fifty years of empirical studies of innovative activity and performance. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the economics of innovation*, 129-213. Amsterdam-Oxford: North-Holland.
- Cohen W. & Levinthal, D. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35 (1), 128-152.
- Cui, A. S. & Fang, W. (2015). Utilizing customer knowledge in innovation: antecedents and impact of customer involvement on new product performance. *Journal of the Academy of Marketing Science*, 1-23.
- Florice, S. & Miller, R. (2003). An exploratory comparison of the management of innovation in the New and Old economies. *R&D Management*, 33 (5), 501–525.
- Hall, B. H., Mairesse, J. & Mohnen, P. (2010). Measuring the returns to r&d. In B. H. Hall & N. Rosenberg (Eds.), *Handbook of the economics of innovation*. 1034-1076. Amsterdam-Oxford: North-Holland.
- Jolliffe, I. T. (2002). *Principal component analysis*. New York: Springer.
- Jovanovic, B. & Rousseau, P. L. (2005). general purpose technologies. In A. Philippe & S. Durlauf (Eds.), *Handbook of economic growth*, 1181-1224. Amsterdam-Oxford: North-Holland.
- Kasztelan, A. (2013). A comparative analysis of the environmental competitiveness of Lubelskie and Zachodniopomorskie Voivodships. *Annual Set The Environment Protection*, 15 (1), 637-648.
- Kasztelan, A. (2010). Environmental competitiveness of regions – Attempt of conceptualization. *Problemy Ekorozwoju*, 5 (2), 77-86.
- Kijek, T. & Kasztelan, A. (2013). Eco-innovation as a factor of sustainable development. *Problemy Ekorozwoju*, 8 (2), 103-111
- Klevorick, A. K., Levin, R. C., Nelson, R. R. & Winter, S.G. (1995). On the sources and significance of inter-industry differences in technological opportunities. *Research Policy*, 24, 185–205.

Kijek, T. & Skrzypek, E. (2017). Technological opportunities and innovation performance: evidence from Polish manufacturing firms. *New Trends and Issues Proceedings on Humanities and Social Sciences*. [Online]. 04, pp 69-76. Available from: www.prosoc.eu

Kijek, T. (2013). External conditions influencing the implementation of eco-innovations in european enterprises. *Annual Set The Environment Protection*, 15 (1), 659-670.

Kijek, T. (2013). Innovation capital as a driver of eco-innovations: A case of european enterprises. In *Proceedings of the 8th European Conference on Innovation and Entrepreneurship (ECIE 2013)*, 1. *Book Series: Proceedings of the European Conference on Entrepreneurship and Innovation*, 363-369. Brussels: Hogeschool Univ Brussel,.

Levin, R. C., Cohen, W. M. & Mowery, D.C. (1985). R & D appropriability, opportunity and market structure: New evidence on some Schumpeterian hypotheses. *American Economic Review Proceedings*, 75, 20-24.

Nelson, R. R. & Wolff, E. N. (1997). Factors behind cross-industry differences in technical progress. *Structural Change and Economic Dynamics*, 8, 205-220.

Nordhaus, W. (1969). Invention, growth and welfare: A theoretical treatment of technological change. Cambridge: M.I.T. Press. Oltra, M. J. & Flor, M. (2003). The impact of technological opportunities and innovative capabilities on firms' output innovation. *Creativity and Innovation Management*, 12, 137-144.

Pakes, A. & Schankerman, M. (1984). An exploration into the determinants of research intensity. In: Griliches, Z. (Ed.), *R&D Patents and Productivity*. University of Chicago Press for the NBER, Chicago, 209-232.

Rosenberg, N. (1974). Science, invention, and economic growth. *Economic Journal*, 84, 90-108.

Rosenberg, N. & Nelson, R. R. (1994). American universities and technical advance in industry. *Research Policy*, 23 (3), 323-348.

Scherer, F. M. (1965). Firms size, market structure, opportunity and the output of patented inventions. *American Economic Review*, 55, 1097-1125.

Smets, L. P. M., Langerak, F. & Rijdsdijk, S. A. (2013). Shouldn't customers control customized product development?. *Journal of Product Innovation Management*, 30 (6), 1242-1253.

Varian, H. (1992). *Microeconomics analysis*. New York: W.W. Norton & Company.