Empirical Paper

Arkadiusz Michał Kowalski*, Marta Mackiewicz

Behavioral additionality: the role of cooperation with research institutions in fostering technological maturity of enterprises

https://doi.org/10.2478/ijme-2022-0009
Received: December 22, 2021; accepted: April 21, 2022

Abstract: The main aim of the article is to examine how cooperation with research institutions influences technological maturity of enterprises. It is accompanied with the additional aim, which is to assess the role of innovation policy interventions in this process, as captured by the concept of behavioral additionality, which is one of the externalities of public support for R&D. The focus of this article is put on one of the specific types of behavioral additionality—cooperation additionality—which takes place in the situation where public support influences the collaboration behavior of a firm receiving R&D support. The study was conducted with the use of firm-level data collected in a survey on the sample of 464 enterprises operating within national smart specializations in Poland. The results of the research suggest that public funding fosters the cooperation between scientific institutions and enterprises, thus confirms the cooperation additionality.

Keywords: behavioral additionality, cooperation, cooperation additionality, innovation, research institutions, technological maturity
JEL Classification: O31, O36, O14

1 Introduction

This article presents the factors influencing the innovativeness of enterprises, with particular emphasis on cooperation between scientific institutions and enterprises and the role of innovation policy in stimulating cooperation in innovation activity, as captured by the concept of cooperation additionality. The research problem is low cooperation level in Polish innovation system, which results in weak technology transfer, negatively affecting innovativeness of the economy. The main aim of the article is to examine how cooperation with research institutions influences technological maturity of enterprises. The additional aim is to assess the role of innovation policy interventions in this process, as captured by the concept of behavioral additionality, which is one of the externalities of public support for R&D. The rationale for the research lies in the contemporary paradigm of open innovation, according to which the new products are mainly the result of cooperation and interactions between actors of innovation systems distinguished in the triple helix model: industry, research institutions, and government. This is being recognized by public administration, which formulate different policy instruments aiming not mainly to increase R&D spending, but mostly to stimulate the relationships between business and research institutions and to induce desired behaviors of firms in terms of their engagement in cooperation activities. This is captured by a concept of behavioral additionality, which, despite the acknowledged importance, remains underexplored in the

***Corresponding author: Arkadiusz Michał Kowalski,** Collegium of World Economy, SGH Warsaw School of Economics, Warsaw, Poland. E-mail: arkadiusz.kowalski@sgh.waw.pl, ORCID ID: 0000-0002-0857-352X
Marta Mackiewicz, Collegium of World Economy, SGH Warsaw School of Economics, Warsaw, Poland.

literature. The originality of the article comes from the use of a data set of primary micro data collected from 464 entities operating in the framework of national smart specializations (NSSs). Moreover, the role of cooperation as a driver for innovation success is being increasingly accepted, but there is a research gap regarding the motivation and effects of science—business cooperation.

The structure of the article is as follows. First, we present the theories related to innovation performance of enterprises, with special focus on the role of cooperation, and smart specialization. In the next section, we describe the research questions, research hypotheses and the variables relevant for examining the technological maturity of enterprises. The descriptive statistics based on the data set from a survey are presented and followed by the formal statistical tests. Finally, we draw conclusions and discuss the reasoning behind a relatively weak relationship between cooperation with research institutions and the technological maturity of enterprises in Poland.

2 Theoretical background

The theoretical background for this research is based on the literature, mostly articles from indexed journals, focusing on the thematic area of the role of science-business cooperation in innovation, and how this can be strengthened by innovation policy, including recent developments in the concept behavioral additionality. As this is relatively new and dynamically developing field of study, the time frame covers mostly the positions published in the last decade.

Today's economic, technological, and social challenges require business entities to be able to build inter-organizational relationships, and inter-organizational cooperation enables its partners to achieve synergies that cannot be achieved by acting individually [Dobrowolska, 2021]. Firm competitive advantage is driven by its ability to develop along with the everchanging business environment by being innovative. Companies, particularly small- and medium-sized enterprises (SMEs), often lack adequate resources to develop innovation, so they search for external resources needed in innovation activity [Tian et al., 2021]. According to the contemporary paradigm in economics of innovation, new products are mainly the result of cooperation and interactions between three types of actors forming triple helix model: industry, university, and government [Etzkowitz and Leydesdorff, 1995]. The triple helix model is one of the most referenced models used to depict an innovation ecosystem, claiming that the boundaries between public and private sectors and between science and industry are increasingly vanishing, leading to a system of overlapping interactions [Pique et al., 2018] engaging:
(1) universities as knowledge-generation subsystem,
(2) industries as the knowledge-exploitation subsystem, and
(3) governments, which acts as the source of contractual relations that guarantee stable interaction and exchange.

The triple helix model, which explores university–industry–government collaborations, is considered as useful in analyzing dynamic interactions between the actors of innovation system that promote innovation and economic growth [Yoda and Kuwashima, 2020]. The concept of innovation systems itself has also inspired discussions in academia and policy alike, leading to a cascading development of approaches to analyze innovation processes and extensions at various analytic levels [Rakas and Hain, 2019]. The general feature of different studies on innovation system is that they emphasize a set of interacting actors working together toward a shared goal of innovation [Lee et al., 2020]. A special form of cooperation are clusters which bring together academic institutions, research organizations or centers of excellence in specific regions, what can be observed mostly in the European Union [Kowalski, 2020]. This approach goes in line with open innovation paradigm, which states that one of the key factors of successful innovation activity is cooperation as the sources of innovation may be found not only inside, but also outside the company [Chesbrough, 2003]. This approach has encouraged the understanding that companies should collaborate with other organizations to leverage their own R&D capabilities. Barrena-Martínez et al. [2020] demonstrated that successful implementation of open innovation strategy depends on the development of relational capital, which allows to benefit from cross-organizational synergies and complementarities. This concept was extended by Chen et al. [2018] to form a new paradigm of innovation, holistic innovation, which is a complex of strategic innovation, collaborative innovation, total innovation, and open innovation, which reflects wisdom from the Chinese context and Eastern culture. Cooperation in innovation activities may take place not only in regional or national economy but also internationally, as reflected in the concept of techno-globalism [Edgerton, 2007].

Although the potential for a “triple helix” to contribute to innovative economy development is being increasingly accepted, university–business cooperation is still a fragmented and underexplored area of research, and the understanding of this cooperation remains insufficient [Galan-Muros and Davey, 2019]. A critical issue in the evolution of the current model of collaboration between universities and businesses in the field of technology transfer is the transition from a closed to an open model of innovation. The issue of using the results of scientists’ R&D work, as well as indicating the directions of research on innovative solutions with high commercialization potential, becomes especially important for entrepreneurs [Rybicki and Dobrowolska, 2018]. There is a growing recognition of universities as a source of not only technology and innovation, but also human capital, reflecting university–business cooperation in education [Orazbayeva et al., 2020]. University–business cooperation is considered as critical to regional economic growth and social prosperity, as they are playing an increasingly more important role in technology transfer, and the marketing of knowledge [Ripoll Feliu and Díaz Rodríguez, 2017]. Hence, policy makers invest significant amounts of public funds to stimulate a strong relationship between business and research organizations as a mean for generating innovation activity [Brem and Radziwon, 2017]. However, the effects of innovation policy instruments depend not only on their characteristics, but also on the context and the process of their implementation [Cunningham and Gök, 2016].

There is a growing research interest on the effects of public intervention on business–university cooperation. Szücs [2018] found a positive effect of a large-scale research subsidy program on the innovation activities of subsidized firms, with a particular regard to industry—university partnerships. Moreover, the benefits of collaborating with universities turned out to be amplified by their academic quality. With continuing technological development, it is not enough to rely solely on internal innovation resources. The existing fragmentation of knowledge in the modern world economy makes an effective innovation activity dependent mainly not only on the internal resources of the organization but rather on an adequate mix of knowledge, skills, and activities of various actors who engage in different forms of cooperation [Kowalski and Mackiewicz, 2021]. Hence, recent science and innovation policy interventions move from simple investments in R&D to incentives that promote innovation cooperation and other behavior of firms, having in mind the complexity of innovation processes [Magro and Wilson, 2013]. This leads to a concept of behavioral additionality introduced by Buisseret et al. [1995], understood as the change in a company’s way of undertaking R&D, which can be attributed to policy actions. Despite the acknowledged importance, behavioral additionality remains underexplored in the literature [Dai et al., 2020]. Behavioral additionality adds to more traditional approaches of additional measurements, that focused solely on input or output measures, thus treating the company as a black box, with no insights into internal processes. As soon as intermediate results such as behavioral changes are explored, the box is opened allowing for a more in-depth analysis of the firm [OECD, 2006].

One of the types of behavioral additionality is network additionality, also referred to as cooperation additionality [Douglas and Radicic, 2022]. Its major role in innovation processes stems from the fact that cooperation creates opportunities to gain complementary resources and skills, and as a consequence, can lead to faster development of innovations [Kubera, 2021]. The innovation collaborative network can be established not only with universities or research institutes, but also with industrial actors, including suppliers, users, complementors and even rivals as well [Guisado-González et al., 2016]. Network additionality can be viewed as a firm-level one-off effect, when a beneficiary firm enters into collaboration only to carry out the subsidized project, or a firm-level persistent effect (e.g., due to a public intervention, a firm changes the pattern in which it cooperates with others); or system-level effect, in the form of, for example, improved coordination [Kubera, 2021].

The study is conducted on firms operating in the framework of NSS. This is justified by the fact that companies are eligible for R&D support if they are active in at least one field covered by smart specialization. Smart specialization (S3) is a policy concept, which aims to address the relations between R&D and innovation ability on the one hand and the sectoral structure of the economy on the other hand. It recognizes the importance of focusing on identified regional strengths to realize the potential for scale, scope, and spillovers in knowledge production and utilization, and consequently increase the productivity of innovation-related activities [Foray et al., 2009]. S3 represents a relatively new strategic orientation of regional innovation policy, reflecting a shift from a "redistributive" toward a "developmental" logic of regional policy, which aims to promote innovation-based endogenous development [Capello and Kroll, 2016]. The rationale to introduce S3 approach is to avoid critical failures of policy developments in the past, like "one-size-fits-all" approach and ignoring the problems of path dependency and lock-in in the analysis of regional innovation systems [Morgan, 2017]. In addition to the category of path extension reflecting the continuation of an existing trajectory, Belussi and Trippl [2018] identified the following patterns of change:

- new path creation, which is about the emergence of new specializations or sectors deriving from breakthrough innovations;
- new path entry of established industries, which is about setting up of an established industry that is new for the region, often based on the inflow of foreign direct investment (FDI);
- path ramification, which is about "speciation" of knowledge by existing industries into new but related industries; and
- path upgrading and renewal, which is about a major change of an industrial path into a new direction based on innovation.

According to Asheim [2019], when designing and implementing a smart specialization innovation strategy, the most important is new path creation, as it is necessary to go beyond considering how to secure "path extension," which was the goal of traditional development policies. To achieve diversified specialization, a region must encourage new path growth, such as diversifying the economy into technologically advanced activities that progress up the knowledge complexity ladder from the region's current level. According to Papamichail et al. [2019], the barriers to implement S3 in catchup regions are the shortcomings in the absorptive capacity of companies that are incapable of exploiting scientific knowledge, critical to meet the objectives of S3. In practice, this is translated into limitations in gathering a sufficient number of science–business propositions that could be implemented in the S3 framework. Additionally, Hassink and Gong [2019] argue that there are insufficient existing structures on which the smart specialization can build, together with poor institutional capabilities when it comes to the selection of the right entrepreneurial discovery process (EDP), understood as a systematic effort of public–private dialog that draws on quantitative and qualitative evidences, focuses on prioritization and action planning, and enables codifying of an emerging regional consensus on cross-sectoral economic development in smart specialization strategies [Benner, 2019]. Furthermore, Balland et al. [2019] pointed out that the operationalization of S3 has been limited because a coherent set of analytical tools to guide the policy directives remains elusive. De Noni et al. [2021] revealed that extending the knowledge complexity of regional portfolio can positively balance the negative effect of technological relatedness in the long-run. Additionally, the results of the study Ghinoi et al. [2021] suggest that different dimensions of proximity, like geographical and cognitive proximity, are positively associated with intra-regional networks aimed at implementing S3.

To conclude, university-business cooperation, in particular in line with the area of economy, smart specialization should be considered as an important element among other factors positively driving the propensity of a firm to innovate, such as Abdu and Jibir [2018]: research and development (R&D), employee education level, trainings, firm's size and age, exporting status, competitors, location, type and sector. While novel technologies may demonstrate significant competitive potential, they also involve certain risks, which decreases together with technology maturity. This reflects technology life cycle model, in which technology is conceptualized as a cycle wherein capabilities and competitiveness arise and decay over time

[Lezama-Nicolás et al., 2018]. One of the most promising approaches for addressing technological maturity is the technology readiness level (TRL), which proves to be helpful in understanding the technological maturity measurements of performance, reliability, durability, and operational experience in the expected environment [Salazar and Russi-Vigoya, 2021].

3 Research objective and hypothesis development, methodology and data

This research focuses on drivers of innovation of enterprises operating in a framework of NSS in Poland. As the factors affecting innovation of enterprises are relatively well recognized and described in the literature, the main research objective is to establish empirically a link between the cooperation with a research institution and the technical maturity of enterprises.

In this article the authors aim to answer the following main research questions:

(1) What are the determinants of enterprise innovation operating in NSS?
(2) How cooperation with research institutions affects the level of technological maturity of enterprises operating within NSS?
(3) What is the relation between public financial support for R&D projects and the cooperation between the research institutions and enterprises, as captured by the concept of behavioral additionality?

To identify the determinants of firm's innovation we analyzed the survey results to examine if the following factors play a role:

(1) participation in R&D projects carried out in cooperation with research institutions,
(2) cooperation with foreign partners in the implementation of innovation or the implementation of R&D projects,
(3) the company's development strategy, considering technological development,
(4) own R&D infrastructure.

The concept of maturity (in the context of an organization, and in particular a company) most often refers to the level of skills and the degree of preparation of the organization to perform specific tasks in a comprehensive manner [Adamik, 2015]. Having specific resources of knowledge along with the ability to correctly define the level of maturity of the organization, may be of key importance for the determination of the paths of long-term development of the organization [Sliż, 2016]. One of the key elements of the company's maturity is its proper technological development, including the use of the modern technologies in the production process. Maintaining the appropriate technological regime and technological readiness (efficiency in the use of available technologies to increase productivity) translates into the level of competitiveness, both in terms of the ability to create innovation and the effects of innovative activity. For this article, we defined the "technological maturity" as a characteristic of an enterprise which is reflected by the following variables:

(1) Technical advancement vs market—the variable based on a self-assessment by the company management related to the advancement of the created or developed technologies in relation to the latest technologies available on the market.
(2) TRL—the variable based on a scale from TRL 1 which means that basic principles were observed to TRL 9 which means that the actual system was proven in operational environment.
(3) Achievements in technology development—the variable measured by awards, distinctions, or other sectoral prizes, like "best product of the year" which are awarded in national, regional, or sectoral competitions or at fairs and exhibitions.
(4) Domestic market position—the variable based on a self-assessment by the company management related to the position of the company among its competitors measured by the market share.
(5) Innovations—the variable measured by the number of implemented innovations.
(6) Patents, trademarks, designs—the variable measured by the number of registered patents, trademarks, and designs.

To answer the second question, we tested empirically the following hypotheses:

- H1: The cooperation with research institutions affects the advancement of the acquired technologies in relation to the latest technologies available on the market and the advancement level of the created or developed technologies according to the level of technological readiness.
- H2: The cooperation with research institutions affects the achievements in technology development.
- H3: The cooperation with research institutions influences the position of enterprises in the industry on the domestic market.
- H4: The cooperation with research institutions influences the number of innovations, patents, trademarks, and designs.

Finally, to answer the third research question, we tested the hypothesis:

> H5: The usage of public financial support for R&D positively influence the cooperation of enterprises with research institutions (the behavioral additionality occurs).

The research methodology used for this article encompasses: (a) a comprehensive analysis of literature and secondary data, (b) a survey among companies on their R&D activity and main outcomes of this activity, and (c) descriptive statistics and formal statistical tests. The article is based on the results of a survey commissioned by the Ministry of Economic Development, Labour and Technology in Poland. The data is not publicly available but can be obtained from the Ministry on request [Ministry of Economic Development and Technology, 2020]. The purpose of the survey was to identify the National Smart Specializations with the strongest potential in terms of technologies used and their innovation output. The survey was carried out in 2020 with the use of Computer Assisted Telephone Interviews (CATI method). There were 43 single-choice or multiple-choice questions in the questionnaire including the characteristics of the company. There were three parts of the questionnaire: (a) exploration of the R&D activity and innovation activity of the company, (b) assessment of technologies developed by the company or purchased, and (c) analysis of the competitive position and the business outcomes. A total of 3478 entities were contacted and 464 entities responded to the survey. The random sample selection was used from the database stratified by smart specialization. The assumption was that all smart specializations are represented and the number of companies in one smart specialization cannot be <10 (which was the case of three specializations). The telephone interview was conducted with a manager, possibly responsible for the development strategy or the R&D department. The pilot of the survey was carried out to verify the assumptions regarding the structure and content of the questionnaire. The surveyed entities operating within the NSS framework employ on average 120 people and the median totaling to 15 people. The number of enterprises that declared cooperation with research institutions is 260.

The data set collected in the survey was a base for descriptive statistics and formal statistical tests. Mann-Whitney and t-test were used to determine if the means of two sets of data (the samples of enterprises cooperating with research institutions and those that did not cooperate) significantly different from each other. The Mann-Whitney test was used for the ordinal data [Hettmansperger and McKean, 1998]. The questions used for the analysis were based both on self-assessment (e.g., market position versus other companies in the sector) and on objective numbers (e.g., number of patents or innovations created).

The research model comprised of the following steps: (1) literature review, (2) drafting research hypothesis based on the literature review, (3) identification of the determinants of enterprise innovation, (4) testing the relation between technological maturity of enterprises and cooperation with research institutions, and (5) testing the relation between the financial support and the cooperation with research institutions on R&D projects.

4 Results and discussion

The surveyed entities used mainly the funds of the Smart Growth Operational Programme. The main assumption of this program was to support the implementation of the entire innovation process:

from the stage of idea creation, through R&D works, including the development of a prototype, to the commercialization of the R&D results. In the financial perspective 2007–2013, a similar role was played by the Innovative Economy Operational Programme; more than a third of the entities participating in the survey benefited from this program.

In the survey, the question was asked whether a company's own infrastructure is sufficient for conducting R&D works as needed. Obviously, not all companies participating in the survey were interested in investing in R&D infrastructure due to the small scope of R&D they carry out. Unmet needs were most often indicated by representatives of the largest enterprises. Above all, they lack laboratory equipment. A big challenge is not only the infrastructure itself, but also the shortage of qualified specialists. This is one of the aspects that limits the R&D activity of the entities participating in the study. Therefore, if it is not possible to carry out specific R&D works on their own, they are fully or partially outsourced to external entities, e.g., research institutes and universities. However, this requires overcoming the barriers that are associated with science-business cooperation.

First, we analyzed the participation of surveyed enterprises in R&D projects carried out in cooperation with research institutions. There are 260 enterprises in the sample that declared such cooperation in the last three years. If the company confirmed the cooperation, the respondent was asked how many times (the number of projects). The majority had just one experience in cooperation (163). In the group of enterprises cooperating with research institutions the majority implemented at least one innovation (85%). In the remaining group (non-cooperative) the share of enterprises implementing innovations was ≤65%. The comparison of firms cooperating and not cooperating with research institutes with respect to different characteristics is presented in Figure 1.

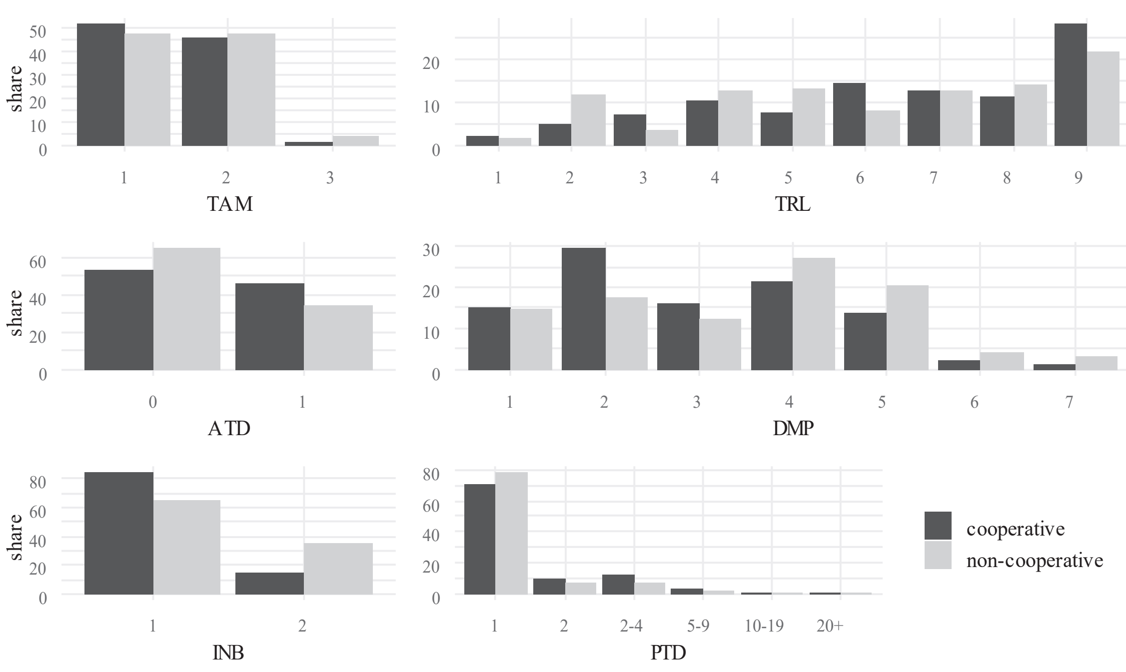

Figure 1. Survey results—comparison of firms cooperating and not cooperating with research institutes. TAM—technical advancement versus other companies operating in the market (answers: 1—Highly advanced, 2—Moderately advanced, 3—Not advanced); TRL—technology readiness level (TRL 1—Basic principles observed, TRL 2—Technology concept formulated, TRL 3—Experimental proof of concept, TRL 4—Technology validated in lab, TRL 5—Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies), TRL 6—Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies), TRL 7—System prototype demonstration in operational environment, TRL 8—System complete and qualified, TRL 9—Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)); ATD (answers: 1—received awards, 0—no awards); DMP—domestic market position (answers from 1—a national leader to 5—very weak market position; 6—don't know; 7—answer refused); INB—innovations (1—innovations implemented, 2—no innovations); PTD—number of patents, trademarks. *Source*: own research.

The comparison of firms cooperating and not cooperating with research institutions (Figure 1) shows that there is higher share of cooperating firms in comparison with not cooperating firms with respect to:

- technical advancement versus other companies operating in the market,
- highest level of technological readiness (TRL 9) of the developed technologies,
- achievements in the field of technology development measured by awards, distinctions, or other sectoral prizes, like "best product of the year" which are awarded in national, regional, or sectoral competitions or at fairs and exhibitions,
- companies which implemented innovations.

The interesting observation is also that when analyzing domestic market position, the share of companies cooperating with research institutes is similar in the case of national leaders (answer 1), companies with significant market share (answer 3) and those with a very weak market position (answer 5).

The survey shows that as a result of cooperation between companies and research institutions established thanks to public support, various changes have taken place in companies. Interestingly, almost every third entity pointed to the fact of establishing cooperation with partners from abroad, which, however, did not necessarily have to be associated with trade exchange (export of goods and services), but with the joint implementation of R&D works. The effects of this cooperation also included an increase in the value of exports and patent applications.

In the sample of 464 entities, 126 enterprises had some experience in cooperation with foreign partners in the implementation of innovation or the implementation of R&D projects. The majority (74%) of these joint R&D projects were successful which means that because of this cooperation, 93 companies implemented market innovations—innovative products or services that were new to the market, not only to the company.

A relatively large share of companies in the sample have a development strategy, in which innovations or technological development are mentioned. In the group of companies that implemented innovations 47% have such a strategy, 42% declared that they report on innovations or technologies and 22% use technology maps or other tools designed for technology development planning. In the second group, enterprises that did not implement innovations, the shares are much lower—16% declared having a development strategy, 10% reporting on innovations or technologies and 8% use some tools for technology development planning.

There are differences in the R&D infrastructure between the groups of innovative and non-innovative companies. More than half of innovative companies use research, measuring and testing devices and every fourth has a laboratory. Infrastructure for prototyping is not frequently used. In the group of non-innovative companies, it is much less, and they do not have R&D centers nor R&D departments. However, enterprises in this group use more frequently advanced computers, servers, and software.

Having discussed the determinants of enterprise innovation and assuming that the participation in R&D projects carried out in cooperation with research institutions is one of them, we tested if cooperation with research institutions affects the level of technological maturity. The results of statistical tests suggest that there are differences between enterprises in the sample cooperating with research institutions and those that did not declare such cooperation (Table 1).

Table 1. The results of Mann–Whitney and *t*-test

Description	Test	Statistic	*p*-value
Technical advancement versus other companies operating in the market	Mann–Whitney	13309	0.38357
TRL	Mann–Whitney	13469.5	0.17806
Achievements in technology development	Mann–Whitney	26290.5	**0.01411**
Domestic market position	Mann–Whitney	19605	**0.00235**
Implementation of innovations	Mann–Whitney	17739	**0.000002**
Patents, trademarks, designs	*t*-test	0.896	0.37074

TRL, technology readiness level.
Source: own research.

The statistical tests are significant for three variables: (a) implementation of innovations, (b) achievements in technology development, and (c) domestic market position.

According to the results of the tests, the hypothesis 1 should be rejected, because technical advancement of the acquired technologies in relation to the latest technologies available on the market is not linked with cooperation with research institutions. Moreover, TRL is not related to the cooperation with research institutions. The test is not significant for TRL, but as it was demonstrated in Figure 1 enterprises cooperating with research institutions more often indicated the highest level of technological readiness (TRL 9) of the created or developed technologies.

Based on the analysis of the collected data and the standard two-sample means test we confirmed hypothesis 2—there is a significant difference between enterprises cooperating with research institutions and not cooperating as far as achievements in technology development are concerned.

There is also formal justification for a positive verification of hypothesis 3—the statistical tests show that domestic market position is related to the cooperation with research institutions. The causality is not determined. It can be assumed that the causal relationship can be two-sided—the higher the position of the company among its competitors measured by its market share, the more motivation and resources for cooperation with research institution. On the other hand—such cooperation can be a trigger for gaining a better market position.

Hypothesis 4 stated that the cooperation with research institutions influences the number of innovations, patents, trademarks, and designs. The conducted analysis did not provide grounds for a positive verification of hypothesis even though formal statistical test shows that both samples differ significantly as far as innovation activity is concerned. Among those companies that co-operated with research institutions 85% indicated creation of at least one innovative product or service. The ratio for the remaining firms was 65% (Figure 2). A Mann-Whitney test confirms the observation. Using a sample of 464 of responses the hypothesis that those groups do not differ was rejected on every conventionally used significance level (p-value 0.000002). However, for patents, trademarks, designs the test was not significant, which means that these innovations are not protected. The reason needs to be further explored. This may be explained by the fact that in joint R&D projects supported by public funds the intellectual property rights stay with the research institution. Another explanation is that these innovations are new to the company, not to the market.

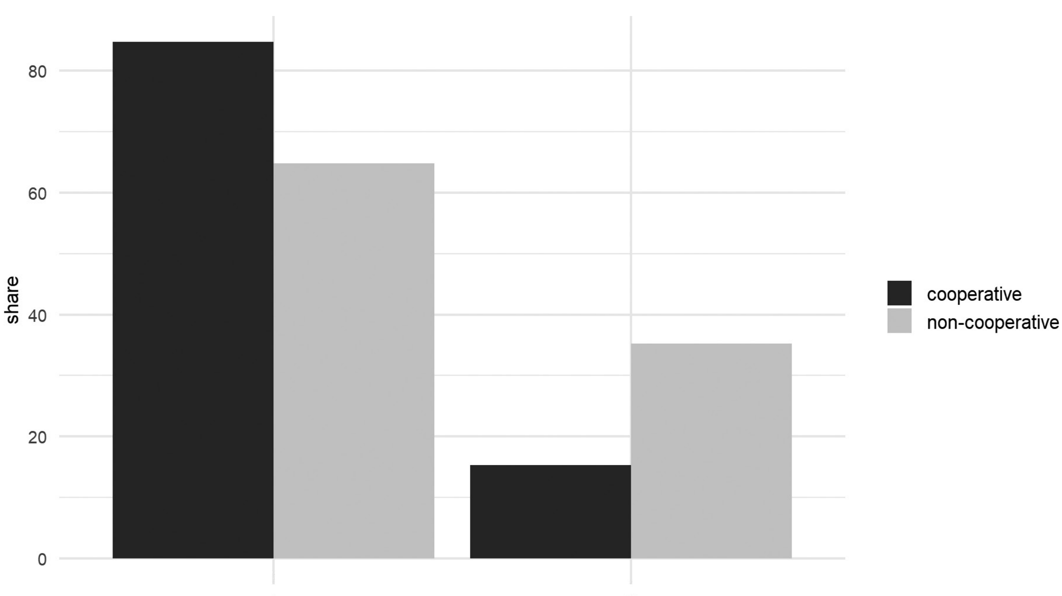

Figure 2. Innovations—comparison of firms cooperating and not cooperating with research institutions. 1—innovations implemented; 2—no innovation implemented.
Source: Own research.

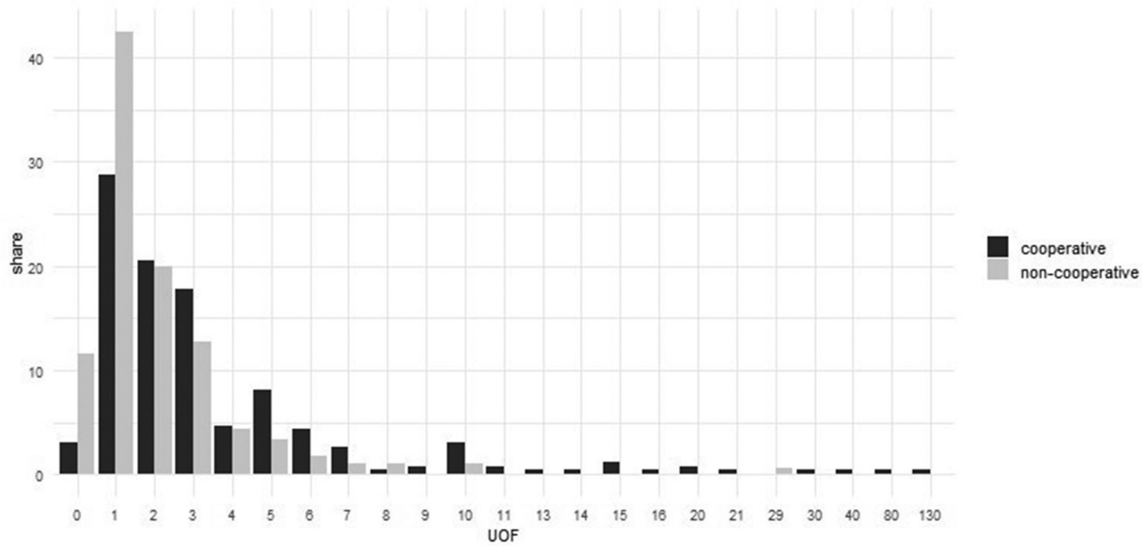

Figure 3. Usage of public support and cooperation with research institutes on R&D projects.
Source: Own research.

The analysis shows that there is a rather weak relation between the cooperation with research institutions and technological maturity of enterprises and the role of research institutions is not reflected in all the aspects selected for evaluating.

In the last stage we tested the existence of behavioral additionality (hypothesis 5). The formal statistical test shows that there is a relation between the usage of public financial support by enterprises and the cooperation with research institutions on R&D projects. Among those companies that co-operated with R&D entities average number of R&D projects carried out in collaboration with research institutes amounts to 4.43. The average for the remaining firms was less than half of that with 2.08. A simple means test confirms what is clearly visible on Figure 3. The t value was equal to 3.02 which at 437 degrees of freedom corresponds with p-value of 0.0026.

The results of the conducted research demonstrate that the usage of public financial support by enterprises positively influence their cooperation with research institutions on R&D projects, which indicate the occurrence of behavioral additionality. These findings confirm the study of Cerulli et al. [2016], who investigated the impact of firm R&D policies supporting R&D investment and collaboration on company innovation performance. This goes in line with the findings of Kowalski et al. [2021] who identified positive effect of European Union funds for innovation activities on the cooperation of enterprises. The research confirms that innovation policy funding for firms positively influence the cooperation with research institutions on R&D projects, which supports the findings of Szücs [2018], who evaluated the impact of a large-scale research subsidy program on the innovation activities of subsidized companies, with a particular regard to industry–university partnerships and found a positive effect on a range of innovation indicators. Leceta and Könnölä [2019] considered potential methodologies, which should allow evaluating impact, including behavioral additionality, of the European Institute of Innovation and Technology intervention. By using microdata, this article fills the gap on microeconomic effects of innovation cooperation between science and business, and additionality of related policy actions.

The study also demonstrates that cooperation with foreign partners fosters implementation of innovations, which is in line with observations on globalization of innovative activities, referred to as the techno-globalism [Kim et al., 2020]. It is motivated by different factors, e.g., the need to search for complementarities in basic and joint applied research based on the increased complexity and intersectoral nature of new technologies, and technical assistance. As it was examined by Arvanitis and Bolli [2013], international collaboration has a substantially greater impact on innovation than national cooperation due to the greater possibility of finding technologically capable partners on a global scale.

5 Conclusion

The conducted research allowed to examine the determinants of innovative performance of enterprises operating within NSSs, with particular emphasis on cooperation between research institutions and enterprises as well as cooperation additionality. The cooperation with research institutions is one of the determinants of innovation performance of enterprises. The results of statistical tests indicate that there is relation between cooperating with research institutions and implementation of innovations by enterprises, achievements in technology development, and a position of a company on the domestic market (assessed subjectively by the management of the company). Among those companies that co-operated with research institutions, 85% indicated creation of at least one innovative product or service. A Mann–Whitney test confirms the observation that the samples of companies cooperating and non-cooperating with research institutions differ with respect to implemented innovations. However, the cooperation with research institutions is not significant for technical advancement versus other companies operating in the market, TRL and the number of patents, trademarks, or designs. This issue could be further investigated to understand the reasons for such results. It can be assumed that if there is a cooperation between the company and the research institution, they need to make an agreement on the intellectual property rights. If the IPR stays with the research institution, the company does not report any patents. Another explanation could be a relatively poor performance of research institutions.

Another finding is that the usage of public financial support by enterprises affects the cooperation with research institutions on R&D projects. A simple means test confirms this finding. Among those companies that co-operated with R&D entities, average number of R&D projects carried out in collaboration with research institutions was more than twice higher than the average for the remaining companies. So, the cooperation additionality has been confirmed. Considering a weak contribution of such cooperation to technological maturity of enterprises, the value of cooperation additionality is questionable.

The limitations of the research are related to the fact that the analysis was made on a sample of enterprises that operate in the framework of NSSs. Hence, it provides the directions for future research that could also encompass companies not acting in NSSs and compare these two groups. Further research could also focus on explaining the reasons behind the cooperation additionality, as it can be assumed that in some funding schemes the partnerships between enterprises and research were encouraged. Additionally, the effects of innovation policy instruments are dependent on the “development” context, which means that collaborative process is not a black box without due regard to the internal processes that produce specific outcomes. Hence, there is no universal set of solutions that would always work in all economies, but different policy actions must be tailored to the needs and characteristics of their implementation, which provides the direction for the future research.

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