

Determinants and Intensity of Science-Business Collaboration

Zbigniew Drewniak, Iwona Posadzińska, Małgorzata Michalcewicz-Kaniowska, Agnieszka Goździewska-Nowicka, Urszula Słupska

Bydgoszcz University of Science and Technology, Bydgoszcz, Poland

zbigniew.drewniak@pbs.edu.pl

iwona.posadzinska@pbs.edu.pl

malgorzata.michalcewicz-kaniowska@pbs.edu.pl

agnieszka.gozdziewska@pbs.edu.pl

urszula.slupska@pbs.edu.pl

Abstract: This article examines the determinants and intensity of science-business collaboration from the perspective of enterprises in Poland. The study addresses a gap in the literature by distinguishing between two analytically different dimensions of cooperation with scientific institutions: the probability that a company engages in collaboration and the intensity of collaboration measured by the number of cooperation forms used by the company. The empirical analysis is based on survey data from 433 enterprises, of which 104 declared at least one form of cooperation with universities or research institutions. The study combines descriptive analysis with two regression approaches. First, a binary logistic regression model is used to identify the factors associated with the occurrence of collaboration. Second, a Poisson regression model is applied to explain variation in the number of collaboration forms declared by companies. The results show that science-business collaboration is strongly differentiated by company characteristics. Medium-sized and large enterprises are significantly more likely to collaborate than small companies, and they also engage in a broader range of cooperation forms. Innovation activity also plays a central role: both product and process innovation increase the likelihood of collaboration, while process innovation in particular is associated with higher collaboration intensity. Among the institutional variables, the perceived competence of university staff emerges as a consistent positive predictor in both models, while access to research infrastructure is especially important for explaining broader collaboration portfolios. The descriptive findings additionally show that collaboration is concentrated among production and service companies and among enterprises with longer market experience. Taken together, the findings indicate that science-business collaboration remains selective and uneven. Cooperation depends not only on companies' internal capacities and innovation orientation, but also on the practical attractiveness of academic partners and the availability of usable institutional resources. The article argues that policies aimed at strengthening university-industry relations should therefore combine support for companies' absorptive and innovation capabilities with efforts to improve the credibility, competence, and infrastructure accessibility of scientific institutions. By separating the occurrence of collaboration from its breadth, the study contributes to a more nuanced understanding of how enterprise-level and institutional factors shape university-industry interaction.

Keywords: Science-Business Collaboration; Innovation; Enterprises

1. Introduction

Science-business collaboration has become an important topic in debates on innovation, competitiveness, and the societal role of universities. In knowledge-based economies, companies increasingly rely on external sources of expertise, while universities are expected not only to produce scientific knowledge, but also to contribute more directly to socio-economic development. As a result, collaboration between scientific institutions and enterprises is now widely treated as a key mechanism supporting knowledge transfer, innovation activity, and the diffusion of research results.

Despite this growing importance, science-business collaboration remains uneven in scope and effectiveness. Some companies engage actively in cooperation with universities and research institutes, whereas others remain outside such relationships or perceive substantial barriers to participation. This makes it important to identify not only the determinants of collaboration itself, but also the factors shaping its intensity. Against this background, the present study examines science-business collaboration from the perspective of enterprises and focuses on the determinants and breadth of cooperation.

2. Theoretical Background

Science-business collaboration has long been recognized as an important mechanism for knowledge transfer, innovation diffusion, and the commercialization of research results. In the literature, this relationship is discussed through several related concepts, including university-industry collaboration, academic engagement, technology transfer, and commercialization. A major contribution of more recent studies has been to distinguish between narrowly understood commercialization activities, such as patenting and licensing, and broader forms

of academic engagement, including joint research, consulting, training, student placements, and other collaborative interactions between universities and companies (Perkmann et al., 2013; Ankrah and AL-Tabbaa, 2015). This distinction is particularly important because many university-business linkages develop outside formal commercialization channels and are embedded in broader relational and organizational processes.

A substantial stream of research has focused on the determinants of university-industry collaboration. Reviews of the field show that collaboration is typically shaped by a combination of company-level capabilities, university characteristics, and institutional conditions. On the side of companies, absorptive capacity, prior innovation activity, organizational resources, and strategic orientation toward external knowledge are consistently identified as important drivers of cooperation. On the side of universities, the competence of academic staff, the relevance of research expertise, and the availability of usable infrastructure increase the attractiveness of scientific institutions as collaboration partners. Broader environmental and institutional factors, such as public support, incentives, and intermediary structures, also influence whether and how such partnerships emerge (Perkmann et al., 2013; Ankrah and AL-Tabbaa, 2015; Rybníček and Königsguber, 2019).

Another major strand of the literature concerns barriers to collaboration. Prior studies show that cooperation between science and business is often constrained by differences in goals, time horizons, organizational culture, and expectations regarding outcomes. Administrative complexity, legal uncertainty, intellectual property concerns, and high transaction costs can further weaken cooperation incentives (Bruneel et al., 2010). demonstrated that many barriers are relational and experiential rather than purely technical, and that previous collaboration experience can reduce some of these constraints over time. More recent contributions also emphasize that barriers vary across stages of collaboration, suggesting that initiation, implementation, and continuation of cooperation may depend on different organizational and institutional conditions (O'Dwyer et al., 2023).

The literature also highlights that successful collaboration depends not only on the presence of resources, but also on the quality of coordination and alliance management. Studies on university-industry relations increasingly stress the importance of trust, communication quality, mutual understanding, and the ability to manage collaborative interfaces. In this view, science-business cooperation is not merely a transactional exchange but a relational process that requires organizational capabilities on both sides. This perspective is especially relevant in studies showing that universities and companies often differ not only in objectives but also in operating logics, which makes intermediary mechanisms and brokerage functions particularly important (Rybníček and Königsguber, 2019; Leischnig and Geigenmüller, 2020)

In parallel, the role of intermediaries such as technology transfer offices, science parks, liaison units, and other brokerage institutions has become more visible in the literature. These actors are expected to reduce coordination costs, facilitate contact formation, support intellectual property management, and improve the translation of academic knowledge into forms usable by companies. Recent reviews suggest that intermediary institutions matter especially where direct collaboration channels are weak, fragmented, or poorly institutionalized. (Friedman and Silberman, 2003; Arroyabe et al., 2025) This strand of research is particularly relevant for analyses that connect enterprise-level collaboration behavior with broader institutional mechanisms supporting knowledge transfer.

The literature also suggests that collaboration should be analyzed as a multidimensional phenomenon. Existing studies often focus either on whether collaboration occurs, on specific channels of knowledge transfer, or on the effects of selected policy instruments. Fewer studies examine, within a single empirical framework, the likelihood of collaboration, the breadth or intensity of collaboration, and the preferences of companies regarding how collaboration should be improved. Yet these dimensions are analytically distinct. The factors that influence entry into collaboration may differ from those that shape the number of collaboration forms, and both may differ from the factors associated with companies' support for specific institutional reforms. This gap provides a strong justification for a multi-model empirical strategy.

The Polish context adds an important institutional layer to this discussion. Research on Poland points to a persistent gap between the formal ambition to build a knowledge-based economy and the practical capacity of universities and companies to cooperate effectively. Analyses of Polish innovation policy suggest that a strong policy emphasis on innovation and commercialization does not automatically generate effective knowledge transfer, especially when institutional incentives, organizational cultures, and channels of interaction remain weak or misaligned (Karpińska, 2020). In this sense, the Polish case is particularly useful for examining not only whether companies collaborate with science, but also which constraints remain most salient and which reforms are perceived as most needed.

At the same time, studies on the entrepreneurial university in Poland show that collaboration with business is increasingly treated as part of the third mission of higher education. Polish contributions emphasize the growing importance of practical cooperation channels, external engagement, and support structures intended to connect universities with their socio-economic environment. However, this literature also indicates that institutional solutions remain unevenly developed and that cooperation often depends on the initiative and capacity of particular units rather than on fully mature systemic arrangements (Bukowska-Piestrzyńska, 2024; Szarek, 2023). This makes Poland a relevant setting for studying the interaction between company-level determinants of collaboration and institutional mechanisms intended to support it.

Against this background, the present study contributes to the literature in two ways. First, it examines science-business collaboration from the perspective of enterprises rather than focusing exclusively on universities or technology transfer offices. Second, it distinguishes between the probability of collaboration and the intensity of collaboration, thereby addressing both the extensive and intensive margins of university-industry interaction. In doing so, the article brings together themes that are often studied separately in the existing literature: determinants and breadth of cooperation.

3. Methodology

The empirical analysis was designed to capture two complementary dimensions of science-business collaboration at the enterprise level: the probability of collaboration and the intensity of collaboration. The models were estimated on survey data from 433 enterprises.

The explanatory variables were selected directly from the enterprise questionnaire. Company characteristics were based on the background questions identifying sector, company size, and company tenure. In the empirical files these variables were coded as sector dummies for production and commerce (with services as the reference category), size dummies for medium and large companies (with small companies as the reference category), and tenure dummies for short and medium company age (with long-established companies as the reference category). Innovation variables were derived from question on the types of innovation introduced during the previous two years, from which product innovation ($InnProd_i$) and process innovation ($InnProc_i$) were selected. The dependent variable in Model 1 was constructed from the block of questions on forms of cooperation with universities and research institutions, coded as a binary indicator equal to 1 if a company declared at least one cooperation form and 0 otherwise. The dependent variable in Model 2 was constructed from the same block as a count of declared cooperation forms. Institutional predictors were selected from question, which asked respondents to assess the importance of specific cooperation-related conditions. From that block the analysis retained access to modern technologies ($Tech_i$), access to research infrastructure ($Infra_i$), competence of university staff ($Staff_i$), opportunities for joint RD projects ($JointRD_i$), opportunities for joint training ($JointTrain_i$), and access to RD funding ($Fund_i$). These variables were included because they correspond directly to the theoretical mechanisms emphasized in the literature on university-industry collaboration.

Model 1 examined whether an enterprise collaborated with scientific institutions at all. The dependent variable was a binary indicator of collaboration, denoted by $Y_i^{(1)}$, coded as 1 if company declared at least one form of cooperation and 0 otherwise. Because the outcome was dichotomous, a binary logistic regression model was estimated:

$$\begin{aligned} \text{logit} \left(P(Y_i^{(1)} = 1) \right) \\ = \beta_1 D_i^{prod} + \beta_2 D_i^{comm} + \beta_3 D_i^{med} + \beta_4 D_i^{big} + \beta_5 D_i^{short} + \beta_6 D_i^{semi} + \beta_7 InnProd_i \\ + \beta_8 InnProc_i + \beta_9 Tech_i + \beta_{10} Infra_i + \beta_{11} Staff_i + \beta_{12} JointRD_i + \beta_{13} JointTrain_i \\ + \beta_{14} Fund_i \end{aligned}$$

Here, D_i^{prod} and D_i^{comm} are sector dummies (services as the reference category), D_i^{med} and D_i^{big} are company-size dummies (small companies as the reference category), and D_i^{short} and D_i^{semi} capture shorter tenure categories. Product innovation is denoted by $InnProd_i$, process innovation by $InnProc_i$, access to modern technologies by $Tech_i$, access to research infrastructure by $Infra_i$, competence of university staff by $Staff_i$, opportunities for $JointRD_i$ by , joint training opportunities by $JointTrain_i$, and perceived access to RD funding by $Fund_i$.

Model 2 extended the analysis from the occurrence of collaboration to its breadth. The dependent variable, denoted by $Y_i^{(2)}$, was the number of forms of cooperation declared by each enterprise. Since the outcome had a count structure, count-data models were considered. The general specification was:

$$\log(E[Y_i^{(2)}]) = \beta_0 + \sum_{k=1}^K \beta_k X_{ki}$$

Both Poisson and negative binomial models were estimated. The Poisson specification was retained because it achieved a slightly better fit, the Pearson dispersion statistic was close to 1, and the overdispersion parameter in the negative binomial model was not statistically significant.

The empirical analysis was guided by the following hypotheses. **H1**: larger enterprises are more likely to collaborate with scientific institutions than small companies. **H2**: product and process innovation increase both the likelihood and the intensity of collaboration. **H3**: higher perceived competence of university staff increases the probability and breadth of collaboration.

4. Results

Before discussing the regression models, it is useful to present the descriptive profile of the surveyed companies and their collaboration patterns. The study covered 433 enterprises, of which 104 declared at least one form of cooperation with universities. As shown in Table 1, the most frequently reported form of cooperation was the organization of internships and placements for students and doctoral candidates, followed by training and workshops for employees. Joint research projects and scientific or technological consulting were less frequent, while technology transfer, licensing, joint publications, and conference presentations were relatively rare.

Table 1: Forms of collaboration declared by enterprises

Form of Collaboration	Number of Companies	Share of Collaborating Companies
Internships and student placements	47	45,19%
Training and workshops for employees	33	31,73
Joint research projects	30	28,85
Scientific and technological consulting	28	26,92
Technology transfer and licensing	14	13,46
Joint publications and conference presentations	2	1,92

Notes: Percentages refer to the 104 enterprises that declared at least one form of collaboration.

Source: own work.

The descriptive breakdown also shows clear differences in collaboration rates across company types. As reported in Table2 , production and service enterprises clearly dominated among collaborating companies, whereas commercial companies were much less represented. Collaboration was also more frequent among medium-sized and large companies than among small companies (Table3). In addition, cooperation was concentrated among companies with longer market experience; companies in the short-tenure category did not report collaboration, while most collaborating companies belonged to the longest-tenure group (Table 4).

Table 2: Collaboration by sector

Sector	Share Among Collaborating Companies	Collaboration Rate Within Sector
Production companies	49.04%	34.93%
Commerce companies	5.77%	10.17%
Service companies	45.19%	20.61%

Notes: The first percentage indicates the share of a sector among companies declaring collaboration; the second indicates the percentage of companies within a given sector that reported collaboration.

Source: own work.

Table 3: Collaboration by company size

Sector	Share Among Collaborating Companies	Collaboration Rate Within Size Class
Small	36.54%	14.50%
Medium	30.77%	30.48%
Large	32.69%	51.52%

Notes: The first percentage indicates the share of a size class among companies declaring collaboration; the second indicates the percentage of companies within a given size class that reported collaboration.

Source: own work.

Table 4: Collaboration by company size

Sector	Share Among Collaborating Companies	Collaboration Rate Within Tenure Class
Short tenure (up to 5 years)	0.00%	0.00%
Medium tenure (5–10 years)	12.50%	17.81%
Long tenure (over 15 years)	87.50%	25.71%

Notes: The first percentage indicates the share of a tenure class among companies declaring collaboration; the second indicates the percentage of companies within a given tenure class that reported collaboration.

Source: own work.

Model 1 shows that the probability of collaboration with scientific institutions is shaped mainly by company size, innovation activity, and perceived competence of academic staff. The model is statistically significant as a whole, with McFadden's pseudo- $R^2 = 0.286$. As shown in Table 5, medium-sized enterprises are about 2.45 times more likely to collaborate than small companies, while large companies have about 4.93 times higher odds of collaboration. Product and process innovation both increase the likelihood of cooperation, and the competence of university staff remains the only significant institutional driver once the full set of controls is introduced. At the same time, enterprises operating in commerce are significantly less likely to collaborate than companies in the reference category. The corrected coding of company tenure makes the coefficient for short-tenure companies numerically unstable because all six companies in that category report no collaboration.

The reduced estimated equation for Model 1, including only statistically significant predictors, is:

$$\log \left(\frac{P(Y_i^{(1)} = 1)}{1 - P(Y_i^{(1)} = 1)} \right) = -6.785 - 1.219D_i^{comm} + 0.897D_i^{med} + 1.594D_i^{big} + 0.803InnProd_i + 1.029InnProc_i + 0.722Staff_i$$

Model 2 shifts attention to collaboration intensity, measured as the number of collaboration forms. The dependent variable has a mean of 0.36, a large share of zeros, and a variance-to-mean ratio of 1.51. The Poisson model outperforms the negative binomial alternative. As shown in Table 6, medium-sized companies display about 1.93 times as many expected forms of cooperation as small companies, while large companies display about 3.12 times as many. Product innovation increases the expected number of collaboration forms by about 83%, and process innovation more than doubles it. Better assessments of university staff competence and access to research infrastructure also increase the breadth of collaboration. By contrast, access to modern technologies has a negative net effect, suggesting that companies already perceiving strong technological access may rely less on a broader portfolio of cooperation channels. As in Model 1, the corrected coding of short tenure leads to an unstable estimate because all six short-tenure companies report zero cooperation forms.

Table 5: Model 1: Logistic regression for enterprise collaboration

Variable	Coef	SE	OR	p-value
const	-6,7846	1,0023	0,0011	0
production	0,2136	0,2991	1,2381	0,4751
commerce**	-1,2191	0,5149	0,2955	0,0179
medium***	0,8972	0,3399	2,4526	0,0083
big***	1,5944	0,3603	4,9253	0
short	-19,4662	14672,04	0	0,9989
semi	-0,1604	0,3851	0,8518	0,677
inn_prod***	0,803	0,2816	2,2322	0,0044
inn_proc***	1,0288	0,2958	2,7978	0,0005
tech_access	-0,1293	0,3006	0,8787	0,6672
infra_access	0,0941	0,3084	1,0987	0,7602
staff_competence**	0,7218	0,3359	2,0581	0,0317
joint_rd	0,1583	0,2282	1,1715	0,4879
joint_training	0,2274	0,2858	1,2553	0,4263
rd_funding	-0,0412	0,2139	0,9597	0,8474
Observations	433			
Pseudo R ²	0,286			
AIC	370,987			

Notes: Full model estimates are reported. Reference categories are services, small companies, and long company tenure. Odds ratios (OR) are shown for substantive interpretation. The estimate for short tenure is unstable because all six companies in that category report no collaboration. Significance markers: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: own work.

Table 6: Model 2: Poisson regression for the number of collaboration forms

Variable	Coef,	SE	IRR	p-value
const	-4,2091	0,5137	0,01	0
production	0,1863	0,1771	1,20	0,2929
commerce*	-0,66	0,3608	0,52	0,0674
medium***	0,6586	0,2206	1,93	0,0028
big***	1,1371	0,2096	3,12	0
short	-19,8075	11428,32	0,00	0,9986
semi	-0,1823	0,2623	0,83	0,487
inn_prod***	0,6026	0,1902	1,83	0,0015
inn_proc***	0,8084	0,1721	2,24	0
tech_access***	-0,5597	0,1676	0,57	0,0008
infra_access**	0,3919	0,1893	1,48	0,0384
staff_competence**	0,5034	0,2026	1,65	0,013
joint_rd	0,1918	0,148	1,21	0,1949
joint_training	0,1235	0,1604	1,13	0,4412
rd_funding	-0,1789	0,1263	0,84	0,1567
Observations	433			
AIC	565,878			

Variable	Coef,	SE	IRR	p-value
Pearson dispersion				0,956

Notes: Full model estimates are reported. Reference categories are services, small companies, and long company tenure. IRR denotes incidence rate ratio. The estimate for short tenure is unstable because all six companies in that category report zero cooperation forms. Significance markers: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Source: own work

The reduced estimated equation for Model 2, including statistically significant and marginally significant predictors, is:

$$\begin{aligned} \log \left(E[Y_i^{(2)}] \right) = & -4.209 - 0.660D_i^{comm} + 0.659D_i^{med} + 1.137D_i^{big} \\ & + 0.603InnProd_i + 0.808InnProc_i - 0.560Tech_i \\ & + 0.392Infra_i + 0.503Staff_i. \end{aligned}$$

5. Discussion

Taken together, the two models provide a coherent picture of science-business collaboration as a process shaped by both company-level capacity and institutional conditions.

Model 1 shows that the transition from non-collaboration to collaboration depends primarily on organizational capacity and innovation orientation. Larger companies are substantially more likely to collaborate with scientific institutions than small companies, and the same is true of companies introducing product and process innovations. This is consistent with the view that collaboration requires not only willingness, but also absorptive capacity, strategic openness, and organizational readiness (Perkmann et al., 2013; Ankrah and AL-Tabbaa, 2015). The significance of university staff competence further suggests that companies enter collaboration when they perceive academic partners as credible, useful, and professionally competent, which aligns with prior findings on the role of university-side capabilities in attracting external partners.

Model 2 demonstrates that these same factors also shape the intensity of collaboration. Larger and innovation-active enterprises not only collaborate more often, but also do so through a broader range of interaction forms. This suggests that collaboration is cumulative: companies with stronger internal capabilities are better positioned to sustain more diversified links with the science sector. The significance of research infrastructure and staff competence reinforces the view that broad collaboration depends on visible and usable institutional resources, not merely on formal opportunities for contact.

From a broader perspective, the results suggest that collaboration should not be treated as a single outcome. The probability of collaboration and the breadth of collaboration are analytically distinct, although both are strongly shaped by company capacity and innovation orientation. This distinction helps explain why some companies do not collaborate at all, whereas others develop a more diversified portfolio of university links. At the same time, the descriptive evidence indicates that collaboration remains concentrated in selected company categories, especially among larger, production-oriented, and longer-established enterprises. This pattern is consistent with the Polish literature emphasizing uneven institutionalization of university-industry cooperation and the selective character of knowledge-transfer relationships.

Overall, the combined evidence from Models 1-2 supports the conclusion that science-business collaboration remains uneven and selective. Larger and innovation-active companies are more likely to collaborate and to do so more intensively. Broad collaboration is also reinforced by favorable assessments of institutional resources, especially staff competence and access to infrastructure. These findings suggest that strengthening science-business relations requires support mechanisms that both expand companies' absorptive and innovation capacities and improve the practical attractiveness of academic partners.

6. Conclusion

This study examined science-business collaboration by distinguishing between the probability of collaboration and the intensity of collaboration. The findings show that collaboration is more likely and more intensive among larger and innovation-active companies. The results also indicate that the competence of university staff and

access to research infrastructure matter for building broader cooperation portfolios, while descriptive evidence confirms that collaboration remains concentrated in selected types of enterprises.

The results suggest that effective support for science-business relations should combine company-targeted measures with improvements in the institutional environment in which universities and enterprises interact. More generally, the study indicates that improving collaboration requires attention not only to company capabilities, but also to the practical usefulness, accessibility, and credibility of academic partners. Questions related to preferred directions for improving cooperation were not examined in depth in this article and may constitute a separate subject for further research in a subsequent study.

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Ethics Declaration

No ethical clearance was needed for the research referred to in this paper.

AI Declaration

In preparing this article, AI tools were used to conduct a systematic review of the literature on forms of collaboration between businesses and academia. The sources have been verified.

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