
Public Support for Industrial Innovation: Evidence from Italy

Sara Berselli*

National Research Council of Italy.
Piazzale Aldo Moro 7, 00185 Rome, Italy.
E-mail: sara.berselli@cnr.it

Stefano Brogi

National Research Council of Italy.
Piazzale Aldo Moro 7, 00185 Rome, Italy.
E-mail: stefano.brogi@cnr.it

Stefano Lucidi

National Research Council of Italy.
Piazzale Aldo Moro 7, 00185 Rome, Italy.
E-mail: stefano.lucidi@cnr.it

* Corresponding author

Abstract: Public funding supports firms' R&D and innovation, often promoting collaboration with Research Institutions (RIs). However, evidence on how collaboration affects different innovation stages is mixed. This paper analyzes 198 firms involved in publicly funded R&D projects in Italy, examining the relationship between firms' collaboration with RIs and three outcomes: patenting, prototyping, and transfer to production. Results show that collaboration is positively associated with prototyping and, to a lesser extent, patenting, especially for SMEs. However, it is negatively associated with transfer to production, indicating challenges in commercialization. These findings suggest a stage-dependent effect: firms' collaboration with RIs benefits early innovation phases, but may hinder downstream outcomes. The study highlights a potential trade-off in collaborative innovation and offers policy and managerial insights for designing more effective R&D support instruments.

Keywords: Innovation management, multi-stage Innovation process; Industry-Research Institutions collaboration; Innovation's public support; *ex-post* innovation outcomes.

1 Introduction

Public funding plays a central role in supporting firms' research and development (R&D) and fostering technological innovation. Governments increasingly use competitive

funding schemes to stimulate private R&D investment, encourage companies' collaboration with Research Institutions (RIs) (universities and research institutes), and reduce the risks associated with innovation activities (Bastos et al., 2021). These instruments are designed not only to support knowledge creation, but also to facilitate the translation of research outcomes into economic and industrial value (Hall and Lerner, 2010; Becker, 2015).

Collaboration between companies and RIs is widely regarded as a cornerstone of contemporary innovation systems and policy frameworks (Rossoni et al., 2024). As technological complexity increases and knowledge becomes more distributed, firms increasingly rely on external sources of expertise to complement internal capabilities and enhance innovation performance (Chesbrough, 2003; Perkmann et al., 2013). Public policies have reinforced this trend by promoting collaborative R&D through competitive funding schemes aimed at fostering both knowledge creation and its economic exploitation (Hall and Lerner, 2010).

However, empirical evidence on the effects of collaboration remains mixed. While collaboration can improve access to knowledge and support exploratory activities, it may also introduce coordination costs and organizational complexity that hinder downstream implementation (Laursen and Salter, 2006). A key factor shaping these outcomes is firms' absorptive capacity (Cohen and Levinthal, 1990), which determines their ability to assimilate and exploit external knowledge.

In parallel, innovation is increasingly conceptualized as a multi-stage process, spanning from knowledge generation to commercialization (Baregheh et al., 2009; Kline and Rosenberg, 1986). This perspective aligns with the exploration–exploitation framework (March, 1991), suggesting that different mechanisms may support different phases of the innovation process.

Despite these advances, relatively limited attention has been devoted to *ex-post* innovation outcomes beyond traditional input indicators, such as R&D subsidies (Yan et al., 2022). Much of the empirical literature relies on measures such as R&D expenditure or patenting, which capture inputs or intermediate outputs rather than realized innovation results (Dziallas and Blind, 2019; Hall et al., 2010). In particular, outcomes such as prototyping and the transfer of project results into production, critical steps for the industrial application of innovation, remain comparatively underexplored (Cubero et al., 2021; Griliches, 1998; OECD/Eurostat, 2018; Wenngren and Rizk, 2024).

This gap is especially relevant within industrial policies characterized by publicly funded R&D programs, which aim to foster both knowledge creation and its commercial application. This study addresses this gap by adopting a stage-based perspective to examine the association between companies' collaboration with RI and three distinct innovation outcomes - patenting, prototyping, and transfer to production-, using firm-level data from publicly funded R&D projects. In doing so, the study is intended to contribute to a more nuanced understanding of the role of collaboration in innovation processes and to inform both academic discourse and strategic policy development.

In particular, the study adopts an exploratory approach based on contingency tables and odds ratios to assess whether collaboration is associated with different innovation outcomes. By explicitly distinguishing between stages of the innovation process, the

paper aims to provide an empirical setting to examine how collaboration between companies and RI is associated with different stages of the innovation process.

To explore these dynamics, this study focuses on projects funded under a national program promoted by the Italian Ministry of Enterprises and Made in Italy (MIMIT), the Sustainable Growth Fund (FCS). FCS is the key instrument for financing the technological and ecological transition of the Italian production system.

The remainder of the paper is structured as follows. The next section presents the backgrounds. Section 3 illustrates data and method. Section 4 presents the results and their discussion. The final section is dedicated to conclusions, suggesting some managerial and policy implications.

2 Backgrounds

Public support to firm-level innovation

Public funding for R&D is a fundamental driver of economic growth, enabling firms to overcome market risks and catalyze technological innovation (Gong et al., 2023). A substantial body of literature has examined the effectiveness of public R&D funding, highlighting both its potential benefits and its limitations. On the one hand, public support can alleviate financial constraints, particularly for small and medium-sized enterprises (SMEs), and incentivize firms to engage in more ambitious and collaborative innovation projects (Czarnitzki and Lopes-Bento, 2014). On the other hand, the impact of such funding on innovation outcomes is not always straightforward, as it depends on factors such as firms' internal capabilities, project characteristics, and the design of the policy instrument itself (Dimos and Pugh, 2016).

In the Italian context, public funding programs promoted by the MIMIT play a key role in supporting firm-level innovation and fostering collaboration between firms and RI. These programs typically combine financial support with explicit incentives for collaborative R&D, aiming to strengthen both technological capabilities and the industrial competitiveness of firms.

FCS encourages sustainability oriented projects and it is built on specific pillars, such as “Environmental Sustainability and the Green New Deal” and “Digital and Sustainable Growth”.

Recent studies emphasize that public funding schemes promoting collaboration may be more effective in supporting early-stage innovation activities, such as research and prototyping, while their impact on downstream outcomes, such as commercialization and production, remains less clear (De Silva et al., 2018). This raises important questions about whether existing policy instruments effectively support the entire innovation process or primarily target specific stages.

In this context, the present study contributes to the literature by examining how collaboration within publicly funded R&D projects is associated with different stages of innovation outcomes, providing empirical insights into the functioning of such policy instruments.

Industry-Research Institutions collaboration as a driver of innovation

Collaboration between firms and RIs has been widely recognized as a key mechanism for fostering innovation in contemporary economies (Abramo et al. 2011; Rossoni et al., 2024). The increasing complexity of technological development and the distributed nature of knowledge have led firms to rely more extensively on external sources of knowledge, particularly universities and public research organizations. This perspective is central to the open innovation paradigm (Chesbrough, 2003), which emphasizes the importance of purposive knowledge inflows and outflows in enhancing firms' innovation performance. Recent reviews confirm that university–industry collaboration remains a central driver of innovation and competitiveness in increasingly complex and digitalized environments (Tereshchenko et al., 2024).

A substantial body of literature has examined the role of university–industry collaboration in shaping innovation outcomes. Studies show that such collaborations can enhance firms' access to scientific knowledge, improve research capabilities, and increase the likelihood of generating novel innovations (Perkmann et al., 2013). More recent empirical evidence further suggests that collaboration can significantly improve firms' innovation performance by reducing uncertainty and facilitating access to complementary resources (Jing, 2024).

However, the evidence on the overall impact of collaboration remains mixed. While some studies find positive effects on innovation performance, others highlight potential drawbacks, including coordination costs, knowledge integration challenges, and misalignment of incentives between partners (Laursen and Salter, 2006). Recent contributions emphasize that such barriers and enablers of collaboration evolve over time and may differ across phases of the collaboration process, affecting outcomes in non-linear ways (O'Dwyer et al., 2023).

One important explanation for these heterogeneous effects lies in firms' internal capabilities. The concept of absorptive capacity, introduced by Cohen and Levinthal (1990), highlights that firms must possess the ability to recognize, assimilate, and exploit external knowledge in order to benefit from collaboration. Firms with higher absorptive capacity are more likely to successfully leverage external partnerships, while those with limited capabilities may struggle to translate acquired knowledge into tangible innovation outcomes.

In addition, the innovation process itself is increasingly conceptualized as a multi-stage and non-linear process, spanning from knowledge generation to commercialization (Kline and Rosenberg, 1986). Within this framework, it is useful to distinguish between upstream activities, such as research, patenting and prototyping, and downstream activities, such as production and market deployment. This distinction is consistent with evidence highlighting that the commercialization of technologies emerging from industry-RI collaborations depends on complex organizational and contextual factors, particularly in the later stages of innovation (Amponsah and Adams, 2017; De Silva et al., 2018). Despite these advances, much of the empirical literature continues to focus on aggregate measures of innovation performance, often overlooking how collaboration affects different stages of the innovation process. As a result, limited attention has been paid to whether collaboration is equally beneficial across all phases of innovation, or whether its effects vary depending on the stage considered (Shi et al. 2020).

This oversight is particularly relevant in the context of publicly funded R&D programs, which frequently promote collaboration between companies and RI as a key policy instrument. While such programs aim to stimulate both knowledge creation and its economic exploitation, it remains unclear whether collaboration effectively supports the entire innovation pipeline or primarily benefits specific stages (Ao et al., 2026).

3 Data and methods

This study relies on secondary analysis of survey data collected by MIMIT from 350 project coordinators, each representing one innovation project funded through a competitive call of the FCS fund aimed at supporting research and development activities in firms. This policy instrument explicitly encourages collaboration with research institutions and aim to foster both knowledge creation and its industrial application.

The call focuses on priority areas identified by the European Horizon 2020 framework, i.e. Sustainable Industry - projects aimed at reducing environmental impact and improving resource efficiency; Digital Agenda - ICT technologies for process digitalization; Key Enabling Technologies (KETs) - fundamental technologies for industrial innovation.

The call, considered in this study, is dedicated to companies, of any size, that are called to submit research proposals as single participant or in partnership with other enterprises or RIs.

The financial support model is a mix between subsidized loan and direct grant.

Technological areas considered in the call are Information and Communication Technologies (ICT); Advanced Manufacturing and Transformations; Advanced Materials; Biotechnologies; Space; Nanotechnologies; Technologies aimed to the achievement of the Horizon 2020 Program “Societal Challenges” priorities.

The evaluation process adopted is constituted by three stages: “*ex ante*”, “*in itinere*” and “*ex post*”. “*Ex post*” phase is aimed to assess the impact of the projects. It is conducted through a questionnaire, which is filled by the beneficiaries and checked by the scientific evaluators.

The questionnaire is aimed at capturing positive *ex-post* outcomes associated with the projects two years after completion. These included measures of innovation performance and broader organizational impacts, allowing for an initial assessment of innovation outcomes. This time lag is consistent with prior studies highlighting that the effects of R&D activities, particularly with respect to production transfer, often materialized with delay (Hall et al., 2010). Since the questionnaires report innovation outcomes at the project level, we restricted the sample to projects involving a unique industrial partner. This selection ensures that outcomes are uniquely attributable to the individual firm, while specifically focusing on the dynamics of industry-RIs collaboration and avoiding the confounding effects of multi-firm consortia. Consequently, the study is based on a final sample of 198 firms. Firms are then divided into two groups based on their involvement in collaboration with RIs. So, the final sample includes 67 collaborating firms and 131 non-collaborating firms. In addition, firms are classified by size into SMEs and large firms, allowing for subgroup analysis.

The study focuses on three binary innovation outcomes: patenting (whether the firm generated patentable results from the project); prototyping: whether the firm developed a prototype; transfer to production: whether project results were successfully transferred into production.

The key independent variable is the collaboration with RI: a binary variable indicating whether the firm engaged in formal collaboration during the project.

These indicators reflect a stage-based view of innovation, spanning from knowledge generation to commercialization (Kline and Rosenberg, 1986).

To assess the association between collaboration and innovation outcomes, the analysis employs 2×2 contingency tables for each outcome variable. This approach allows for a direct comparison between collaborating and non-collaborating firms and is commonly used in exploration analyses of categorical data (Agresti, 2013).

For each outcome, the following statistics are computed: Outcome rates (percentages) for collaborating and non-collaborating firms; Odds ratios (OR), measuring the strength and direction of the association between collaboration and the outcome; 95% confidence intervals (CI) for the odds ratios; p-values, derived from appropriate statistical tests.

Given the categorical nature of the data, the combined use of chi-square tests and odds ratios represents a standard approach for analyzing associations between binary variables and interpreting effect sizes (Sogunle and Sogunle, 2020).

Statistical analysis was performed using MedCalc Statistical Software at the website <https://www.medcalc.org>

Due to the relatively small sample size and the presence of low expected cell counts in some subgroup analyses, Fisher's exact test is used where appropriate, while chi-square tests are applied in cases with sufficiently large, expected frequencies (Agresti, 2013).

To explore potential heterogeneity, the analysis is replicated separately for SMEs and Large firms. This allows for assessing whether the association between collaboration and innovation outcomes differs across firm size, which is particularly relevant given differences in internal resources and capabilities.

The adopted methodology is intentionally descriptive and exploratory. While contingency tables and odds ratios provide intuitive and interpretable measures of association, they do not allow for controlling for potential confounding variables. Moreover, the relatively small sample size, especially within subgroups, limits statistical power and leads to wide confidence intervals. Accordingly, the analysis focuses on identifying associations rather than establishing causal relationships. Future research could extend the analysis using multivariate techniques, such as logistic regression models, which allow for the estimation of relationships between multiple predictors and binary outcomes while accounting for confounding factors and improving inferential robustness (Dey et al., 2025).

In addition, the use of survey-based, self-reported data may introduce potential biases, including recall bias and response bias. While this approach allows capturing outcomes not observable through administrative data, the results should be interpreted with caution.

4 Results and discussion

This section presents and discusses the association between collaboration with research institutions and firms' innovation outcomes across three stages: patenting, prototyping, and transfer to production.

Table 1 Collaboration with Research Institutions and Innovation outcomes

<i>Innovation Outcome</i>	<i>Sample</i>	<i>N (Total; Collab / Non-collab)</i>	<i>Collab (%)</i>	<i>Non-collab (%)</i>	<i>Odds Ratio (OR)</i>	<i>IC 95%</i>	<i>p-value</i>
Patenting	Total firms	198; 67/131	19.4%	16.0%	1.26	[0.59, 2.71]	0.552
	SMEs	137; 54/83	18.5%	9.9%	2.07	[0.76, 5.65]	0.149
	Large firms	63; 13/50	23.1%	26.0%	0.85	[0.2, 3.59]	1
Prototyping	Total firms	198; 67/131	68.7%	58.0%	1.59	[0.85, 2.95]	0.146
	SMEs	137; 54/83	70.4%	56.8%	1.81	[0.87, 3.75]	0.112
	Large firms	63; 13/50	61.5%	60.0%	1.07	[0.3, 3.73]	0.920
Transfer to production	Total firms	198; 67/131	79.1%	87.8%	0.53	[0.24, 1.16]	0.108
	SMEs	137; 54/83	74.1%	86.4%	0.45	[0.19, 1.08]	0.071
	Large firms	63; 13/50	100.0%	90.0%	3.26	[0.17, 62.87]	0.574

The results show that collaboration is associated with higher levels of upstream innovation activities. In particular, collaborating firms report a higher rate of prototype development compared to non-collaborating firms (68.7% vs. 58.0%; OR = 1.59). A similar, though weaker, pattern emerges for patenting (19.4% vs. 16.0%; OR = 1.26). These patterns are more pronounced among SMEs, where the odds ratios reach 2.07 for patenting and 1.81 for prototyping, suggesting that smaller firms may benefit more from access to external knowledge and capabilities. This is consistent with prior evidence highlighting the role of collaboration in enhancing firms' innovation potential, particularly when internal resources are limited (Audretsch and Belitski, 2020; Chesbrough, 2003; Perkmann et al., 2013).

These findings can be interpreted through the lens of absorptive capacity (Cohen and Levinthal, 1990). Firms engaged in collaboration may be able to effectively absorb external knowledge for early-stage innovation activities, such as prototyping, without necessarily possessing the capabilities required to fully exploit that knowledge in more complex downstream processes. In this sense, absorptive capacity may enable firms to benefit from exploratory collaboration activities, without necessarily ensuring successful exploitation in later stages (Cassiman and Veugelers, 2006).

In contrast, collaboration is associated with lower rates of transfer to production. Collaborating firms report lower levels of production transfer compared to non-collaborating firms (79.1% vs. 87.8%; OR = 0.53), with a similar pattern observed among SMEs (74.1% vs. 86.4%; OR = 0.45).

Although these differences are not statistically significant, they are relatively consistent and suggest the presence of a potential trade-off in collaborative innovation processes. One possible explanation is that collaborations with RIs tend to emphasize exploratory and knowledge-intensive activities, which may not be fully aligned with market-oriented objectives or operational scalability. This interpretation is in line with the distinction between exploration and exploitation in organizational learning (March, 1991), and with recent evidence highlighting coordination and implementation challenges in collaborative R&D (De Silva et al., 2018). This pattern suggests that collaboration may facilitate knowledge creation without necessarily ensuring its effective industrial application. An alternative explanation is that more complex or ambitious projects, more likely to involve collaboration, also face greater difficulties in reaching the production stage due to uncertainty and coordination costs (Vivona et al., 2023). Thus, the observed pattern may reflect project characteristics rather than the effect of collaboration itself.

Overall, the results suggest a stage-dependent association between collaboration and innovation outcomes. Collaboration appears to be more strongly associated with early-stage innovation activities, such as patenting and prototyping, while its association with downstream phases, such as production and commercialization, is weaker or even negative. This pattern is also consistent with prior evidence showing that external collaborations, while beneficial for knowledge creation, may introduce coordination costs and complexity that affect downstream performance (Laursen and Salter, 2006).

Given the exploratory nature of the analysis, the results should be interpreted as indicative associations rather than causal effects. The relatively small sample size, particularly in subgroup analyses, limits statistical power and calls for caution in generalizing the findings.

5 Conclusions

This study provides evidence on the differentiated role of companies' collaboration with RIs across stages of the innovation process. The findings suggest that collaboration is associated with stronger performance in early-stage activities, such as prototyping and, to a lesser extent, patenting, while it is associated with lower rates of transfer to production.

The findings suggest that collaboration should not be viewed as a uniformly beneficial strategy, but rather as a context-dependent mechanism whose effectiveness varies across stages of innovation. In particular, while collaboration may enhance firms' ability to access and apply external knowledge, it does not automatically translate into successful commercialization or production scaling. This interpretation is consistent with the broader literature on open innovation (Chesbrough, 2003), as well as with the distinction between exploration and exploitation in innovation processes (March, 1991).

From a managerial perspective, firms, especially SMEs, can benefit from collaboration in developing new knowledge and technologies, but should also invest in internal capabilities that support the integration and exploitation of external knowledge. In this respect, the concept of absorptive capacity (Cohen and Levinthal, 1990) provides a useful framework for understanding why collaboration may generate uneven outcomes across stages of the innovation process.

From a policy perspective, the findings suggest that instruments promoting collaborative R&D may need to be complemented with mechanisms specifically targeting downstream phases, such as scaling and industrialization. This is particularly relevant in the context of publicly funded innovation programs, where the ultimate objective is not only knowledge creation, but also the successful translation of research results into economic value.

Even if the results should be interpreted with caution due to the exploratory nature of the analysis, the relatively small sample size, and the use of self-reported data, the consistency of the observed patterns suggests that the findings capture meaningful dynamics worthy of further investigation. Future research could build on these findings by employing larger samples and multivariate approaches to better understand the mechanisms linking collaboration, absorptive capacity, and innovation outcomes across different stages of the innovation process.

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