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Unleashing the power of collaboration: strategies for effective innovation management

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Introduction

Innovation is a crucial factor in the progress of business and society: Dedication to innovation initiatives is becoming essential for organizations in their quest for a value that transcends mere profits, thereby generating positive impacts on society and the environment.

Previous research on innovation management literature investigated several ways through which innovation can be created, managed and disseminated. Across three chapters which adopt different perspectives, this thesis tries to address how to deal with innovation management, and hence aim at understanding how innovation can be adopted and under which conditions it can be a critical choice for firms.

We are aware that there is no single strand of literature that addresses these issues, and we struggled with the issue of where to position ourselves. In the first and the last chapter, we explicitly use the term Open Innovation and refer to that strand of literature. In the second chapter, instead, we do not explicitely refer to Open innovation as the theoretical background is more related to the study of Research Joint Ventures, e.g. the analysis of European Framework Programmes (FPs), which indicates that the R&D research projects does not rely on this term.

Open Innovation has made a stronger mark and can clearly be defined as a strand of literature after twenty years of research on the topic. Furthermore, this concept has been increasingly revised and broadened over time to encompass many forms of collaborative innovation**.**

Therefore, there is no shared understanding of what the boundaries between each term are, as sometimes these terms are used interchangeably between research communities which struggle to communicate. Consequently, given the existing overlap between the various research on these topics, I decided to define Collaborative Innovation as a summary concept.

Collaborative Innovation (CI) refers to the involvement of organizations in joint strategies and activities, representing the integration of collaborative innovation activities in business models, with the aim of creating value for the organization while at the same time benefiting the economy, society, and environment.

Companies engage in CI for various reasons. First, it drives the engagement and long-term corporate orientation of organizations. Companies use CI to demonstrate their commitment to their stakeholders; this engagement tends to be rewarded when the company's claims are aligned with the actual benefits for the economy, society, and environment. Furthermore, CI signifies a long-term orientation that is more beneficial over time than short-term, non-

innovative strategies. This long-term focus encourages adaptability, knowledge sharing, and technological advancements, which have become crucial for portfolio strategies and investor decision-making.

Second, CI fosters knowledge sharing and a culture of continuous learning. The implementation of CI strategies allows companies to access diverse perspectives and expertise, which in turn leads to breakthrough ideas that might not otherwise have been discovered internally. Working with external partners enhances collective intelligence, thereby enabling companies to create more effective and innovative products and services. Additionally, CI promotes a culture of continuous learning, which encourages organizations to stay abreast with the latest trends, technologies, and best practices in their industry. This collaborative mindset cultivates adaptability and resilience, and thus helps companies thrive in a competitive business landscape. Third, it promotes efficiency and competitiveness. It can lead to increased efficiency and reduced time-to-market for new products and services because of having pooled resources, knowledge, and expertise. This optimizes research and development processes, minimizes the duplication of efforts, and accelerates the innovation cycle. Despite the potential costs of CI strategies, the balance between these costs and benefits still needs to be carefully investigated. Ultimately, this collaborative approach enhances competitiveness and positions organizations on the global market for long-term success.

In the pursuit of developing products and activities that emphasize CI, companies can utilize various frameworks and platforms, such as open innovation, research joint ventures or ecosystems. These frameworks guide organizations and institutions toward the adoption of innovative practices by highlighting the key objectives and areas of focus.

This study endeavors to tackle these aspects by concentrating on innovation, particularly Open Innovation and Inter-organizational networks, such as the European Framework Program. As a key catalyst in the global economy, innovation fuels the adoption of Open Innovation and collaborative networks across diverse sectors, thereby promoting inclusive progress. The aims of these innovation initiatives encompass:

• Maximizing the potential of technological and knowledge resources

• Respecting and leveraging on the diverse perspectives and expertise of organizations across networks

• Ensuring long-term, viable economic operations that provide benefits to all the involved parties and promote inclusive progress (European Innovation Scoreboard)

The dedication of organizations to CI, especially in the realm of open innovation, is aimed at fulfilling these goals, as the innovation facets emphasized by companies correspond to the

principles of cooperative development. Nonetheless, the propagation of innovation practices among global enterprises is not a foregone conclusion, as companies navigate complex institutional settings that can either foster or obstruct the practical execution of these practices in relation to CI strategies presented at the corporate level.

In response to the propositions, this thesis delineates two primary research objectives. Primarily, it seeks to understand whether the execution of collaborative strategies, specifically Open Innovation and Interorganizational Networks, has the capacity to impact the financial performance of firms. It posits the hypothesis that the successful attainment of innovation objectives could potentially be correlated with an enhancement in financial performance or, exclusively, with an augmentation in the realm of innovation (e.g., as intangible assets). Secondarily, the study aspires to comprehend the degree to which the presence of the same manager and advisor across diverse firms leads to the propagation of uniform innovation models, aimed at pursuing a collaborative mode, and what the role of a company's characteristics is in such a replication of models.

The thesis is structured as follows: the first chapter scrutinizes the role of the Open Innovation (OI) paradigm in achieving the strategic innovation objectives of firms within the context of the Italian manufacturing and service sectors, which have been recognized for their high innovation propensity in several reports, including the European Innovation Scoreboard. Adopting an institutional theory perspective and employing a mixed-methods approach that encompasses both qualitative and quantitative analyses on empirical data, the study explores the interplay of such external factors as market competition and institutional roles, and internal dynamics such as innovation climate and implemented innovation processes, in shaping the impact of OI on the financial performance of firms. The research findings indicate that the mere deployment of OI on its own is not enough to bolster financial outcomes. Instead, these outcomes are potentially compromised by limited managerial focus on such strategies. Furthermore, the research suggests that the positive relationship between OI and financial performance is favorably moderated by the presence of supportive business practices, a competitive market environment, and an encouraging domestic public sphere. This implies that firms that embrace OI, along with these supportive elements, yield superior financial returns than those that are solely engaged in innovation-focused activities, thereby suggesting a more integrated and focused approach toward innovation strategies.

The second chapter explores the influence of a firm's engagement in Information and Communication Technologies (ICTs) framework programs (FP) on its intangible investment, revenue growth, and employment growth. An extensive examination of a diverse sample of

firms, some involved in FPs and others that are not, has revealed that various internal and external factors either facilitate or impede the successful implementation of innovation-focused activities. Data were aggregated from firms participating in ICT related FPs, including some of the prominent players on the market. The findings indicate that firms that engage in ICT related FPs witness greater growth in intangibles, revenue, and employment than those that do not. Furthermore, the heterogeneity of FP research group participants emerges as a significant determinant of the success of funded activities. Projects characterized by diverse participants demonstrate a higher propensity for success, as they are better positioned to harness knowledge and skills from various sources to generate innovative solutions. These insights hold significant implications for policymakers and firms that seek to augment their performance via FP participation. By promoting diversity among FP participants, these programs could bolster a firm's competitiveness and growth.

In the final chapter, the investigation delves deeper into the influence of board composition and the network of advisors on the open innovation (OI) models adopted by organizations. Drawing on theories of isomorphism, the study examined board isomorphism as a dynamic process interlinked with the broader context of a board's social network and its relationship with the organization's innovation models. Employing a mixed-method approach, the author adopted semi-structured interviews, questionnaires, and secondary data to measure the OI models of organizations and to explore the commonalities among them. Through a social network analysis, the research demonstrates that organizations can exhibit proactive or passive behaviors when they implement OI activities, according to the similarity of their board composition and advisory networks. Logistic regressions were employed to evaluate the impact of shared board members and advisors on the adoption of analogous innovation models within a specific industry. The dependent variable represented the similarity in the OI model within each dyad, and it distinguished between collaborations inside and outside the value chain, while the independent variables consisted of the networks of board members and advisors. The results corroborate that interlocking directorates facilitate the transfer of knowledge and ideas, and consequently influence the exploration and implementation of innovative models. The study further contributes to our understanding of the different types of isomorphisms and their implications on innovation. It sheds light on how an isomorphism can bolster innovation capabilities and it underscores the importance of board composition and external advisory networks in shaping innovation models within the field.

Chapter 1: Enabling an effective Open Innovation strategy for financial growth: the mediating role of internal and external firm drivers[1]

Keywords: Open Innovation, Mediation, Employees, Environment, Firm Performance

Abstract. The open innovation paradigm presents a promising opportunity for firms to obtain their strategic innovation objectives. However, the effectiveness of open innovation in sustaining superior financial performance remains a subject of debate. Specifically, our study examines how external factors, such as competition in market and role of institutions, and internal dynamics, such as innovation climate and innovation processes implemented, mediate the impact of open innovation on financial performance. Relying on empirical data, the phenomenon has been analysed from a qualitative and quantitative viewpoint, integrating different methodological approaches. The research is grounded in the Italian manufacturing and service sectors, sectors considered high innovative in many reports including the European Innovation Scoreboard. The paper contributes to the literature by showing that OI implementation, together with innovation-supportive business practices, a competitive external market, and a supportive domestic public environment, positively affect the financial performance of firms.

1. Introduction

Open Innovation (OI) has emerged as a promising strategy for technology management and performance in the field of management. However, the mixed results observed in the literature regarding its impact on financial outcomes have raised practical concerns and highlighted the need for further research in this area.

In today's rapidly changing and highly competitive business environment, firms are recognizing the importance of leveraging external knowledge and technologies to drive innovation and achieve sustainable growth. OI, as introduced by Chesbrough in 2003, represents a departure from the traditional closed innovation model and emphasizes the willingness of firms to collaborate with external parties to access and exploit new ideas and technologies.

[1]This paper has been presented at the WOIC Conference 2022, High Tech Campus, Eindhoven, The Netherlands

Despite the growing interest in OI, there are still gaps in our understanding of how internal and external factors influence the financial performance of firms that adopt OI practices. The existing literature has provided mixed and inconclusive findings, necessitating further investigation to shed light on the mechanisms underlying the relationship between OI and financial outcomes.

The primary objective of this study is to examine the influence of internal and external factors on the financial performance of firms adopting OI. To achieve this objective, we aim to answer the following research questions: *Do internal factors, such as innovation climate and practices, impact the adoption and effectiveness of OI in improving financial performance? Do external factors, such as the national environment and competitive market, mediate the relationship between OI and financial performance? How this occur?*

This study holds significant implications for both academia and practitioners in the field of management. By addressing the gaps in the literature and providing empirical evidence on the relationship between OI and financial performance, this research contributes to the theoretical understanding of OI and its impact on firm outcomes. Moreover, the findings of this study can guide managers in formulating effective strategies for implementing OI practices and optimizing financial performance.

This study is grounded in established theories and concepts from the field of management, such as Chesbrough's OI paradigm, the resource-based view of the firm, and innovation theories. These theoretical foundations provide a conceptual basis for understanding the mechanisms through which internal and external factors influence the adoption and effectiveness of OI.

The research methodology employed in this study is a mixed-methods approach. We adopt an embedded mixed method design (Creswell and Clark, 2007) as disciplined methodological pluralism (Landry and Banville 1992; Weber 2004). As regard to the quantitative part, we collected data through a survey administered to firms in the manufacturing and information and communication technologies (ICTs) services sectors. The survey was designed based on existing literature and measured various dimensions of OI, internal factors (e.g., innovation climate, practices), and external factors (e.g., national environment, competitive market). The collected data were analysed using statistical techniques, including structural equation modelling, to examine the relationships between the variables and test the research hypotheses. We incorporated qualitative data in our study that predominantly focuses on quantitative data to further explore our findings. Regarding the qualitative part, we conducted interviews to verify and support the findings obtained in the quantitative phase. The sample consists of 12 Italian-based firms, selected on the basis of the following characteristics: (i) adopters of best

practices; (ii) recognized reference point for their innovation activity; (iii) achievement of good performance, despite the economic crisis.

The remainder of this paper is organized as follows: Section 2 provides a comprehensive review of the relevant literature on OI, internal and external factors, and financial performance. Section 3 presents the research methodology, including the survey design, data collection procedures, and analytical techniques employed. Section 4 presents the results of the analysis, discussing the findings in relation to the research objectives and questions. Section 5 offers a discussion of the implications of the findings for theory and practice. Finally, Section 6 concludes the paper, summarizing the main findings, highlighting the contributions of the study, and outlining directions for future research.

In conclusion, this study aims to contribute to the existing body of knowledge on OI: by examining the influence of internal and external factors, this research provides valuable insights into the mechanisms underlying the relationship between OI and firm performance. By understanding the factors that influence the adoption and effectiveness of OI, firms can enhance their innovation capabilities and competitiveness in the dynamic business landscape.

2. Theoretical Background

The term Open Innovation (OI) was introduced by Chesbrough in 2003, indicating the willingness of firms to exploit knowledge and technologies that exist outside their business and grant external parties the use of ideas and technologies that they cannot or do not want to exploit. Chesbrough's (2003) identified a new paradigm for organising the innovative activity of the firm, as opposed to the 'closed innovation' model. The progress of this new paradigm (Chesbrough, 200'; Chesbrough and Bogers, 2014) is attributed to the boost generated by several phenomena: increased mobility of workers, increased quality of universities, decline of US hegemony, easier access to venture capital for start-ups and the rise of the internet (Chesbrough, 2003).

The open innovation model manifests itself as an evolution of various theories in the economic literature (Cohen and Levinthal 1990; Nelson, 1975; Kenneth Arrow, 1962; Rosenberg, 1994; Levinthal and March, 1993) and it has been largely explored in the last years. Nevertheless, unexplored points remain. Previous literature has failed to clarify the specific mechanisms for firms to absorb external knowledge, nor has the possibility of firms opting to transfer unused internal knowledge externally been considered.

For the sake of our work, previous contributions can be grouped into two macro-categories as follows: (i) investigations into the factors behind the adoption of OI; (ii) analysis of the ways in which OI practices influence firms' financial performance. This research project stands contributions in both categories.

2.1. *Factors behind OI adoption*

Recent research has shown the need to study OI at different levels of analysis, as this phenomenon has implications for the way innovation activities take place at the individual, firm, inter-organisational and broader sector, or region level (Bogers et al., 2017; Chesbrough and Bogers, 2014; West et al., 2014). Therefore, factors have been studied looking at internal as well as the external elements such as the institutional context in which the firm operates and is embedded (Chesbrough and Bogers, 2014; Pinarello et al., 2022; Puliga et al., 2023). Among those, literature identified positive aspects (enabling factors) and negative aspects (barriers to adoption) of OI. Among the positive ones, we can identify the human enablers (e.g., leadership, collaborative climate, trust, friendship, personality of team members), which are the elements inside the firm (both in terms of people and processes) that facilitate the adoption of open innovation practices. On the side of the negative aspects, we find the human obstacles, mirroring the enablers, which act as hindering elements of the innovation process within the firm (not invented and not shared syndromes).

	ENABLERS	OBSTACLES
INTERNAL	Leadership, collaborative climate, trust, friendship, personality of team members	Not invented and not shared syndromes
EXTERNAL	Local or national business support policies, territorial competence centres, clusters, and ecosystems	Economic crises, non-collaborative ecosystems, poor internationalization, and technological or market

Table 1. Enablers and obstacles for the adoption of OI

Table 1 summarize the enablers and obstacles as they emerge from the literature. Among the internal factors, one strand of literature examines the adoption of OI practices (both inbound and outbound) according to the degree of appropriation of the benefits of the final innovation (Gassmann and Enkel, 2006). Moreover, it is possible to identify a second strand of research that focuses how the characteristics of an organisation that may influence its ability to adopt OI strategies. Such characteristics might concern structural aspects – such as size or age -, strategic aspects – such as the level of investment in research and development – or aspects

related to organisational contingencies – such as the degree of aversion to knowledge flows generated by OI. (Tranekjer and Knudsen 2012). Such latest stream identified several measures to explore and quantify such factors.

According to the literature, internal factors influencing the firm's innovative activity can be classified into different processes and indicators. The "not-invented-here" syndrome and internal organizational relationships are indicators of the attitude of the firm's employees toward knowledge and technologies from the external environment (Katz and Allen, 1982; Tranekjer and Knudsen, 2012). According to Popa et al., (2017) innovation climate is a process that quantifies the number of business practices aimed at improving the innovativeness of the organization. Several authors have pointed out that analyzing the characteristics of firm employees that influence the degree of openness of innovative activity is a factor that has yet to be explored (Amabile, 1988; Levinthal, March, 1993; Mumford et al., 2010). Bogers, Foss and Lyngsie (2018) have shown that heterogeneity in the educational level of employees is a factor positively and directly related to the degree of openness of innovative activity. In contrast, the degree of difference in the work experiences of the same employees is indirectly related to inbound strategies and amplifies the impact of educational heterogeneity. In addition, the authors call for research on the effects of HR organizational practices, which have not yet been adequately considered and studied in relation to open innovation activities. Besides internal factors, literature also identified a series of external elements that influence the possibility to successfully implement OI practices.

The implementation and adoption of open innovation practices are influenced not only by internal factors but also by external elements, such as environmental enablers and obstacles. Environmental enablers refer to the elements of the external context that facilitate the implementation and adoption of open innovation, such as local or national business support policies (Cano-Kollmann et al., 2017), territorial competence centres, clusters (Kim and Altmann, 2022), and ecosystems (Ferreira et al., 2023). Conversely, environmental obstacles are those hostile elements of the innovation process that are beyond the control of firms, such as economic crises (Zaidan et al., 2022), non-collaborative ecosystems (Ponchek, 2016), poor internationalization (Santoro et al., 2021), and technological or market uncertainties (Garcia Martinez et al., 2017). The presence of these obstacles can render the adoption of open innovation ineffective or, at the very least, dissipate its effects.

The literature primarily focused on the drivers or enablers that lead to successful collaboration, and there is still a dearth of scientific evidence on the failures generated by the obstacles to collaboration between organizations and firms. As such, more research is needed to better

understand the challenges and obstacles that hinder the implementation and adoption of open innovation practices (Puliga et al., 2023).

2.2. *OI practices and firms'performance*

The second stream identified above includes studies on the effect of OI practices on performances. Performance can be analysed from a variety of viewpoint, such as the innovation success, measured as the share of turnover from the sale of innovations in a reporting period, or the financial performance, measured as the effect of OI practices on financial measures.

Previous research has shown mixed results on the efficacy in the adoption of Open Innovation on performance. The human side (Bogers et al., 2018) in combination with other factors such as the innovation climate, and the external environment, could trigger positive effects.

While most of these studies have focused on the inbound dimension of OI, some have also considered other variables. For instance, Cassiman and Veugelers (2006) examined the complementarity between externally acquired knowledge and in-house R&D. Laursen and Salter (2006) studied the costs and benefits of knowledge search strategies and discovered that excessive openness can lead to sub-optimal innovation performance. Parida et al. (2012) analyzed the importance of inbound practices for SMEs and highlighted how the acquisition of intellectual property is associated with radical innovations, while the firm's assessment of technology trends is more associated with incremental innovations.

Cassiman and Valentini (2015) investigated whether combined engagement in knowledge buying and selling can enhance innovation performance. However, they found no empirical evidence to support this complementarity, and they discovered that as knowledge purchases and sales increase, R&D costs increase more than proportionally.

Some studies have also examined the relationship between OI practices and the firm's environment. Hung and Chou (2013) observed how the degree of change in product demand amplifies the impact of inbound and outbound OI practices on the firm's financial performance, while the speed with which technology changes only amplifies the positive impact of inbound practices. Ahn et al. (2017) identified the positive effect that OI can have in overcoming obstacles such as turbulence in the external environment. They found that the search for knowledge outside the firm's boundaries helped their sample of British firms to become more resilient in a time of economic crisis. Additionally, they found that the most fruitful relationships were those with knowledge carriers far removed from their own.

Overall, these studies suggest that OI practices can impact a firm's performance, but the specific nature of this impact depends on various factors such as the type of knowledge being

acquired or the firm's external environment. Further research is needed to fully understand the complex relationship between OI and performance.

3. Research Questions and Hypothesis

Previous literature showed that OI alone do not always has a positive effect on financial performance, while it is often observed that OI leads to an increase in the firm's operating costs (Cassiman and Valentini, 2015; Faems, 2010). Furthermore Bogers et al. (2018) pointed out that OI require a cultural predisposition, which otherwise the risk is to obtain adverse effects and a limitation to the firm's openness. Moreover, beside the human side of OI (Bogers et al., 2018), scholars agree that also the external context in which the firm operates and is immersed (Chesbrough and Bogers, 2014) plays a role in influencing the effectiveness of OI implementation.

The interrelations and the existence of a mediation effect between environmental effects and internal practices and their effect on financial performance remain partially unknown. Therefore, we aim to answer to the following research questions: *Do internal factors, such as innovation climate and practices, impact the adoption and effectiveness of OI in improving financial performance? Do external factors, such as the national environment and competitive market, mediate the relationship between OI and financial performance? How this occur?*

This work questions whether the mediation between internal activity (i.e., innovation climate and practices fostering R&D) and the external environment (i.e., the competitive environment and the institutional context), enable OI to have a positive effect on financial performance. Answers will be provided using a mixed method approach. To answer the above-described questions, we will use qualitative data to test the following two hypotheses that we developed. In the first hypothesis we propose that the mediation effect of innovation climate and practices to Open Innovation, that positively influence firm's financial performance. The second hypothesis suggests that the mediation effect of the external environment to OI, positively influence financial performance.

H1. the mediation effect of innovation climate and practices to Open Innovation, positively influence the financial performance of the firm.

H2. the mediation effect of the external environment to Open Innovation, positively influence the financial performance of the firm.

Qualitative data will be used to corroborate quantitative findings and to gain a deeper understanding of how internal and external factors mediate the effect of OI on financial performance.

4. Methodological approach

We employed a mixed-methods approach for data collection and analysis, adhering to the guidelines by Creswell (2003) and Creswell and Clark (2017). The study encompassed two phases: a survey and interviews. In the quantitative phase, we devised a survey grounded in various indicators identified in the literature, aiming to gather quantitative data on the pertinent variables. Simultaneously, in the qualitative phase, we conducted interviews with selected participants to corroborate the survey findings and obtain supplementary qualitative data.

The administration of the survey and the scheduling of the interview occurred concurrently. Interviews were held either in-person or through video conferencing, with participants chosen via purposive sampling. To ensure data validity and reliability, we employed a blend of quantitative and qualitative data analysis techniques, including content analysis for the interview data. The survey and interview outcomes were triangulated to augment the credibility of our findings (Greene et al., 1989). Overall, the mixed-methods approach facilitated the collection of both quantitative and qualitative data, offering a comprehensive understanding of the research question.

The robustness of a mixed-methods approach lies in its ability to offset the limitations of each individual method while capitalizing on their strengths (Johnson, Onwuegbuzie, & Turner, 2007). This synergy enables researchers to achieve a more holistic understanding of complex phenomena and enhances the validity of their findings (Creswell, 2009). By integrating both quantitative and qualitative data, mixed-methods research fosters the triangulation of data sources, which bolsters the credibility and confirmability of the results (Denzin, 1978; Patton, 1999). Furthermore, this approach is valuable for cross-validating findings, as the convergence of diverse data sources increases the confidence in the study's conclusions (Jick, 1979).

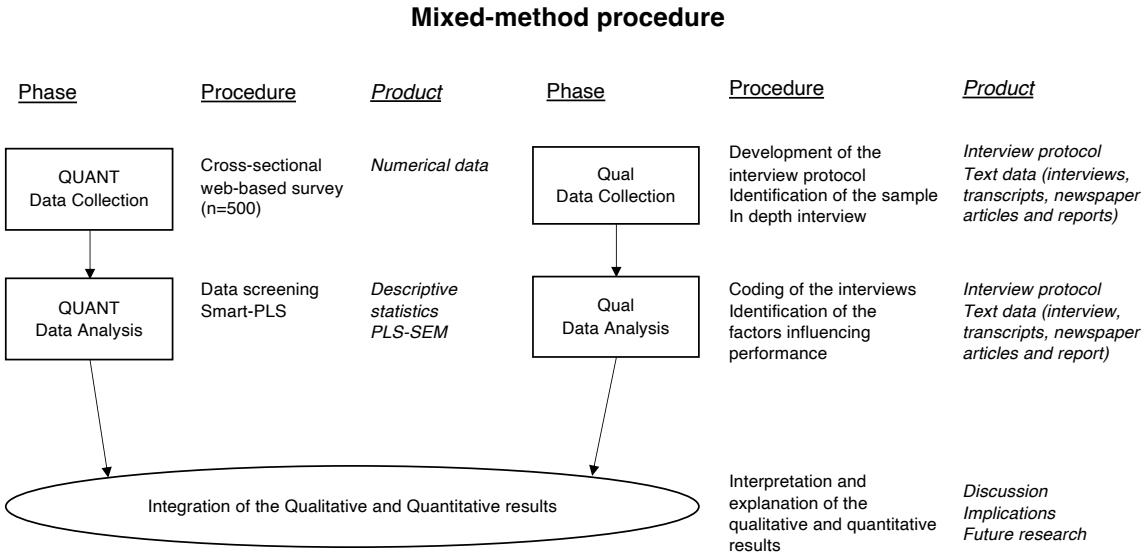

Figure 1. Methodological process adopted, source: authors' elaboration, 2023

5. Quantitative study

The quantitative study is based on the data collected through a survey, integrated with secondary data taken from public database. Firstly, we constructed various indicators based on existing literature. As acknowledged by West, Salter, Vanhaverbeke and Chesbrough (2014), one of the major tests related to the study of this phenomenon concerns its measurement. Its multidimensionality makes it impossible to identify a single quantity that can summarise it. To obtain a dataset consistent with the context we want to explore, we designed an ad hoc survey to measure some specific aspects otherwise unmeasurable. An example is the survey by Tranekjer and Knudsen, (2012) who, to measure business syndromes (Katz and Allen, 1982) implemented a questionnaire designed to construct indicators related to these dimensions. Hence, we tested our hypotheses using a combination of two data sources, a questionnaire, and secondary data. Departing from the items present in the literature (Laursen and Salter, 2006; Dahlander and Gann, 2010; Popa et al., 2017; Ahn, Mortara and Minshall, 2017), a questionnaire was developed for representative firms in the manufacturing and information and communication services sectors. In both sectors, innovation is of significant strategic importance. In fact, among the sectors covered by the Community Innovation Survey, the share of firms that have introduced product and/or process innovations is higher in manufacturing and service industries than in all major industries. Moreover, analyses of structural differences in countries' economies consider the difference in the share of these two sectors as relevant factors explaining why a country may perform better or worse in indicators such as business

R&D spending, patents, and the number of innovative firms. The questionnaire is composed by 24 questions each of which has several items, for a total of 100 different items, including information about the respondent and identifying information about the enterprise. The questions used were taken in part from the Community Innovation Survey, and covered the firm's innovative factors, IO practices, organizational practices, internal employee practices, and the firm's perception of the external environment. Questionnaire is available upon request. Interviews for the questionnaires were conducted through the Computer-Assisted Telephone Interviewing (CATI) method, by a professional contractor. The sampling procedure considered three dimensions of a firm: i) industry (Manufacturing and ICT); ii) size based on the number of employees (50-250 and >250); and iii) geographical location (Northwest, Northeast, Central, South). The maximum sampling error was small (e=1.8%; α=0.95%). The response rate obtained was about 30 percent. With the responses received, it was possible to construct a series of indicators, to capture the various dimensions of openness in firms' innovative processes and analyse possible correlations with the financial performance of the sample firms.

5.1. *Definition of variables*

The variables (see Table 3) in the model include both latent constructs, measured using composite multi-item scales, and observable measures assessed through single-item indicators. A description of the variables follows. The independent variables are four, two measure external factors while the other two measure internal factors. External factors are measured as follows: (i) *National Environment:* this variable measure the extent to which external factors, such as public institutions and other organizations within the country, contribute to the firm's competitive advantage. To measure the national environment variable, participants' responses to survey items were used. Specifically, participants were asked to evaluate the impact of public institutions located in the rest of Italy and other firms located in the rest of Italy on their firm's competitive advantage. These items provided insights into the influence of the national environment on firms' competitive advantage.

The second external factor is: (ii) *Competitor Influence.* This variable assesses the degree of competitiveness exhibited by the firm's rivals and the overall level of competition within the relevant local market. The variable was operationalized based on participants' responses to survey items. Participants were asked to rate their agreement with statements regarding the external environment's competitiveness. The responses were measured on a Likert scale ranging from 1 to 5, capturing the extent of agreement or strength of agreement with the

statements. These items were adapted from existing scales and allowed for an evaluation of the influence of competitors on firms' operations.

Internal factors are measured as follows: (i) *Innovation Climate:* this variable examines the degree to which the firm implements business practices aimed at fostering a positive attitude towards innovation among its employees. It was operationalized using a combination of survey items. Participants were asked to indicate the presence or absence of certain practices in their firms. These practices included pecuniary incentives to encourage employees to develop their own ideas/inventions, informal and formal business practices aimed at incentivizing idea development and communication of opinions and suggestions, practices for identifying and developing talented employees, staff training for team building, and the existence of heterogeneous work groups with open communication. These items were adapted from established sources, including previous studies.

Similarly, the (ii) *Innovation Practices* variable was operationalized by participants' responses to survey items. The items explored the implementation of specific business practices within the enterprise. These practices encompassed innovative project management, including methodologies such as stage-gate, milestones, design thinking, and agile; monitoring of innovative projects using Key Performance Indicators; fostering experimentation of new ideas through practices like Proof-of-Concept budgeting; and the implementation of IP management practices such as patenting, patent licensing, and patent portfolio analysis. The measurement items for this variable were derived from existing literature and validated scales.

In the model we have two dependent variables, one related to innovation and the second related to performance, as follows: (i) *Open Innovation (OI)* variable was created using a single-item indicator derived from participants' responses. Participants were asked whether their firm had established collaboration agreements regarding innovation activities with other firms or institutions. This item provided insight into the presence or absence of OI practices within the firms. The second dependent variable is (ii) *Financial Performance.* This variable evaluates the firm’s financial performance in terms of key indicators. To measure firms’ financial performance, we relied on secondary data, either by obtaining them from proprietary databases (Bureau Van Djik) or balance sheet data and firm’s financial performance ratios. As a measure of financial performance we used the Return on Equity (ROE) obtained by the firm in the year following the interview. ROE is a financial indicator that measures the return on investment made by shareholders in a firm and is a measure of the firm's ability to generate profits.

Overall, the operationalization of these variables involved adapting items from established sources, including the Community Innovation Survey and previous studies by Tranekjer and

Knudsen (2012). This approach ensured the relevance and validity of the measurement items used to capture the various dimensions of innovation climate, innovation practices, national environment, competitor influence, and OI within the research model.

5.2. *Descriptive analysis*

The first stage of the analysis involves describing the dataset, highlighting the distribution of firms. Those with higher financial performance are the same ones that report implementing OI, innovation support practices, and fostering an innovation climate. However, when the internal variables (practices and climate) are replaced with external environment variables, a different distribution is observed. Specifically, the firms with better financial performance are not the ones implementing OI and being influenced by the external environment. Instead, it is the other firms that alternate between these two conditions.

	↑ O.I. - ↓ Practices	↓ O.I. - ↑ Practices	↑ O.I. - ↑ Practices	↓ O.I. - ↓ Practices
Return on Equity (ROE)	10,63% (n = 25)	10,69% (n = 115)	**18,41% (n = 68)**	9,12% (n = 278)
	↑ O.I. - ↓ Innovation Climate	↓ O.I. - ↑ Innovation Climate	↑ O.I. - ↑ Innovation Climate	↓ O.I. - ↓ Innovation Climate
Return on Equity (ROE)	12,18% (n = 35)	12,17% (n = 129)	**18,81% (n = 58)**	8,31% (n = 264)
	↑ O.I. - ↓ Competitor	↓ O.I. - ↑ Competitor	↑ O.I. - ↑ Competitor	↓ O.I. - ↓ Competitor
Return on Equity (ROE)	**17,72% (n = 71)**	12,01% (n = 76)	11,75% (n = 22)	8,99% (n = 317)
	↑ O.I. - ↓ National Environment	↓ O.I. - ↑ National Environment	↑ O.I. - ↑ National Environment	↓ O.I. - ↓ National Environment
Return on Equity (ROE)	**18,95% (n = 49)**	11,77% (n = 168)	13,38% (n = 44)	7,94% (n = 225)

Table 2. t-test for internal and external variables

To illustrate this further, Table 2 presents the results of a statistical test comparing the means of the observed groups. The table showcases the combinations of Open Innovation with internal drivers (innovation climate and practices) and external drivers (competitor influence and national environment). In the third column, we find firms that implement both Open Innovation and internal practices while being influenced by the external environment. Strikingly, this combination leads to a subgroup of firms with higher profitability compared to the rest. However, when the same analysis is performed using measures of the external environment,

the outcomes diverge. Firms reporting Open Innovation implementation and external influences do not exhibit superior financial performance.

Several ANOVA (Analysis of Variance) and Scheffé tests were performed to test the significance of diversity among each group analysed. These are two statistical tools used to test whether there is a significant difference between the data groups analysed.

The ANOVA test is used to assess whether the mean of at least one of the groups differs significantly from the means of the other groups. This test assumes that the variances of the groups are homogeneous, and that the data are normally distributed. The null hypothesis is not rejected, and none of the groups has a mean significantly different from the others. Scheffé's test is used as a post-hoc test to determine which groups differ significantly from each other in case of significant results in the ANOVA test, but this is not the case.

5.3. *PLS estimation model*

The variance-based PLS-SEM (Partial least squares structural equation modelling) approach is used to test the hypotheses by analysing the relationships between variables in a theoretical model, and to understand how these variables affect the dependent variable. It is often used in the business and social science fields to analyse data collected through questionnaires and surveys. It allowed the theoretical model developed at the beginning of the research, the working hypothesis describing the relationships between the variables in the study, to be reported on the software. It will be represented in the next section graphically through an arrow diagram (path diagram) showing the variables and their interactions (fig. 2). The collected data were placed within the individual constructs and analysed the relationships between them and assessed the significance of these relationships.

The analysis of the model involved several important steps to ensure its reliability and validity. First, the measurement model underwent evaluation and reliability assessment. This included measuring the Cronbach's alpha to evaluate internal consistency and assessing the variance extracted from the latent variables. To perform these analyses, we utilized the SmartPLS v.3.3.2 software package (Ringle, Wende, & Becker, 2015).

Additionally, robustness tests were conducted to ensure the accuracy and effectiveness of the model. These tests involved examining the collinearity of the variables using the Variance Inflation Factor (VIF) with a threshold value of less than 5. The external weight and external load of each indicator were also assessed to determine their relative and absolute importance, respectively. To assess the significance of the indicators, bootstrapping with 5,000 runs was employed, following the approach outlined by Hair et al. (2016). Furthermore, the model fit

was evaluated using the Standardized Root Mean Square Residual (SRMR), as recommended by Hu and Bentler (1995). Heterotrait-to-Monotrait (HTMT) ratios, with values less than 1.0, were considered to ensure discriminant validity, following the guidelines proposed by Henseler, Ringle, and Sarstedt (2015). To quantify the standard errors and further validate the model, 5,000 bootstrapping runs were performed, as suggested by Hair et al. (2014). These rigorous analyses allowed us to thoroughly assess the reliability, validity, and effectiveness of the measurement and structural models in accordance with the Partial Least Squares Structural Equation Modeling (PLS-SEM) methodology.

The evaluation and reliability phase of the measurement model examines the collinearity of the indicators to evaluate the formative measurement indicators, which must have a VIF of less than 5. Having measured the external weight (relative importance) and external load (absolute importance) of each indicator, bootstrapping is then used to assess their significance. Having obtained a significant weight for the selected indicators or a relatively high corresponding element load (i.e., >=0.50), these are retained for construct creation. Table 3 provides the final list of individual elements used in the analysis and their loadings. All items demonstrate good individual reliability by showing statistics above the cut-off suggested in the literature.

Constructs	*Items*	*Loadings*	*VIF*
National Environment	*How did the following external factors contribute to your firm's competitive advantage during the three-year period 2019-2018?*		
22B	Public institutions located in the rest of Italy	0,882	1,043
22E	Other firms located in the rest of Italy	0,641	1,043
Competitors' Influence	*How much do you agree on a scale of 1 to 5 with the following statements about the outdoor environment?*		
21D	Your firm’s competitors are highly competitive	0,874	1,507
21E	The degree of competition in the relevant local market is high	0,903	1,507
Innovation Climate	*Could you please indicate whether in your firm:*		
19B	Are adopted informal business practices aimed at encouraging employees to develop their own ideas/inventions for the enterprise	0,753	1,678
19C	Are implemented formal practices aimed at encouraging employees to communicate their opinions and suggestions for the improvement of the organisation and its strategies	0,700	1,501
19D	Are adopted informal firm practices aimed at encouraging employees to communicate their opinions and suggestions for the improvement of the organisation and its strategies	0,756	1,615
19E	There are formal firm practices aimed at identifying, rewarding, and growing within the firm the most talented employees	0,719	1,572
19F	There are formal corporate practices of staff training aimed at strengthening the ability to work in groups (team building and teamwork)	0,594	1,331

	19G	There are working groups whose composition is heterogeneous, and within which there is total freedom of communication among members	0,64	1,389
	19I	Firm employees often perform nonrepetitive and complex tasks that require the use of their creativity to be accomplished	0,649	1,330
Practices		*Could you please indicate whether:*		
	20A	The firm has implemented business practices for innovative project management (e.g., stage-gate methodologies, milestones, design thinking, agile)	0,76	1,343
	20B	The firm has implemented business practices for monitoring innovative projects (e.g., Key Performance Indicators)	0,769	1,355
	20C	The firm has implemented business practices to encourage experimentation with new ideas (e.g., budgets for Proof of Concept)	0,674	1,246
	20D	The firm has implemented IP management practices (e.g., patenting, patent licensing, patent portfolio analysis)	0,622	1,212
Open Innovation				
	9A	Has the firm established collaborative agreements regarding innovation activities with other firms or institutions in the last three years?		1,000
Financial Performance				
		Return on Equity (ROE)		1,000

Table 3. The constructs for PLS model

After confirming the reliability and validity of the constructs' measurements, we test the structural model. We examined the predictive ability of the model and the relationships among the constructs to check for collinearity. As shown by the result of measuring the model fit to assess its effectiveness, the Standardized Mean Quadratic Residual (SRMR), and the VIF less than 5, the constructs are not collinear.

The heterotract to monotract ratios (HTMT) were considered and are found to be less than 1.0. The model reported an SRMR of 0,072, which as suggested in the literature should be less than 0.08 (Henseler et al., 2014; Hu & Bentler, 1995). Table 4 reports the correlation matrix of the constructs and the Table 5 show the significance between each construct considered in the model through p-value, standard deviation, and the mean.

	1	2	3	4	5	6
(1) National Environment	-					
(2) Competitors' influence	0,072	-				
(3) Financial Performance	0,123	0,020	-			
(4) Innovation Climate	0,305	0,259	0,129	-		
(5) Practices	0,209	0,207	0,126	0,604	-	
(6) Open Innovation	0,190	0,056	0,122	0,278	0,458	-

Table 4. Heterotrait-monotrait ratio of correlations (HTMT)

	Original sample (O)	Sample mean (M)	Standard deviation (DEVST)	Statistics-t (|O/DEVST|)	P-values
N.E.-> Innovation Climate	0,166	0,172	0,042	3,920	**0,000**
N.E. -> Practices	0,111	0,111	0,047	2,382	**0,018**
C.I. -> Innovation Climate	0,201	0,208	0,04	5,017	**0,000**
C.I. -> Practices	0,147	0,154	0,043	3,421	**0,001**
Innovation Climate -> OI	0,109	0,108	0,051	2,138	**0,033**
Practices -> OI	0,334	0,336	0,048	7,005	**0,000**
OI -> Financial Performance	0,122	0,123	0,054	2,254	**0,025**

Table 5. Summary of the relation between the constructs

To test the ability of the constructs to predict what is expressed in the hypotheses are analysed the relationships predicted in the theory and other related variables. The sign and significance of the path coefficients assess the construct's prediction validity. Using the bootstrapping 'sampling with replacement' method, the statistical significance of parameter estimates is assessed. Standard errors were calculated considering 5000 bootstrapping runs (Hair et al., 2016). The results of the structural model through a graphical representation are shown in Figure 2.

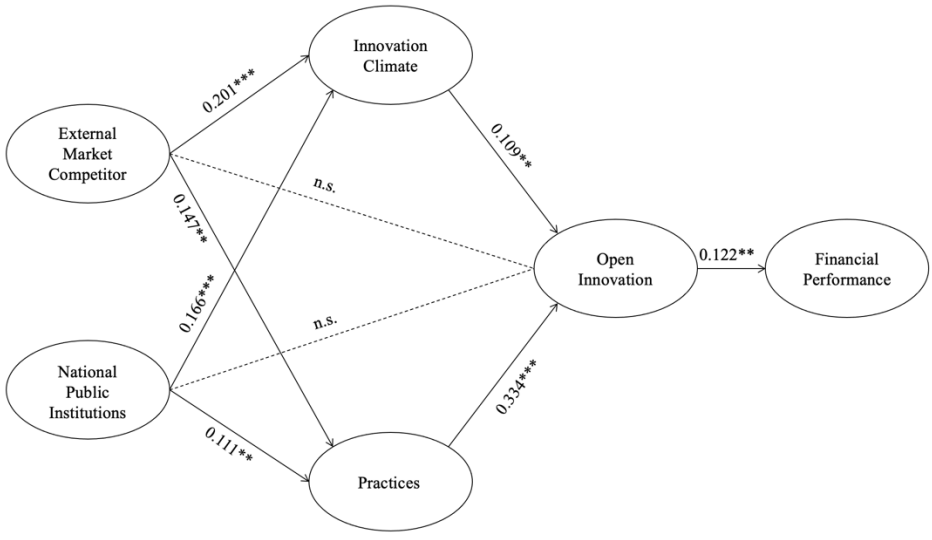

*Figure 2. The model using PLS-SEM. N=500 * p < 0.1; ** p < 0.05; *** p < 0.01, source: authors' elaboration, 2023*

Hypothesis H1 examined the mediating effect of innovation climate and practices on Open Innovation and its positive influence on financial performance (FP) of the firm. The analysis revealed significant and positive effects between innovation climate and OI (B = -.109, p < .038), practices and OI (B = -.334, p < .000), and from OI to FP (B = -.122, p < .017). These

findings support Hypothesis H1, indicating that the presence of an innovation climate and the implementation of supportive practices contribute to the effectiveness of Open Innovation, ultimately enhancing the firm's financial performance.

Hypothesis H2 posited that the mediation effect of external drivers on Open Innovation positively influences the firm's financial performance. The model incorporates external factors such as market competitiveness and domestic competition. The results demonstrate a positive effect on firm performance, suggesting that favourable external conditions alone are not sufficient for effective Open Innovation. The mediation analysis indicates that the presence of internal factors, including innovative practices and climate, is necessary for external influences to translate into improved financial performance. Thus, Hypothesis H2 is rejected, emphasizing the importance of internal enablers in conjunction with external factors for Open Innovation to yield positive financial outcomes.

These findings underscore the crucial role of implementing business practices and cultivating an innovative climate in the successful implementation of Open Innovation strategies. The external factors, although not directly influencing Open Innovation and financial performance, act as mediators that enhance the effectiveness of the outcomes. The significance of the joint mediation effect is further supported by Figure A and B in appendix, where the direct influence of the internal and external drivers loses significance.

This pattern aligns with the previous results observed using the t-test, where firms engaged in Open Innovation and influenced by the competitive market, or the national institutional environment did not exhibit superior performance. While there may not be a significant direct effect between the external environment and Open Innovation, the results highlight the crucial role of both internal practices supporting innovation and the external environment in determining firm performance.

6. Qualitative study

6.1. *Data collection and analysis*

In the qualitative phase, we adopted a multiple case study methodology to support the findings emerged from the quantitative study. We collected and analyzed data obtained through qualitative interviews to develop a deeper understanding of the role of both internal practices supporting innovation and the external environment in determining firm performance.

The qualitative sample is composed of 12 Italian-based firms (Table 6), selected on the basis of the following characteristics: (i) adopters of best practices recognized nationally and internationally; (ii) recognized, by the business community, as a reference point for their innovation; (iii) having the ability to achieve good performance, despite the economic crisis. The firms' names have here been kept confidential. Their identification was guided by the knowledge and experience of the group of researchers and by consulting secondary and documentary sources. Following the identification of the sample, we conducted exploratory interviews with a representative of each firm. The following criteria were used for the selection of the interviewees: high level of knowledge (i) of the internal innovative processes of the firm, (ii) of the external relations and (iii) enough experience within the firm to be able to select the most representative innovation project. 9 interviews were conducted face to face, while 3 were conducted using teleconferencing technologies. The average length of each interview was 51 minutes. All the interviews were recorded and transcribed verbatim, in order to be able to proceed with a text analysis through coding. Details of the interviews are provided in Table 6.

	Firm	**Length**	**Location**	**Interviewer**	**Role of the interviewee**
1	Alpha	51'	Pescara	FC	Vice President
2	Beta	27'	Milan	MR	CEO
3	Gamma	68'	Skype interview	VM, EF	Director of OI
4	Delta	73'	Anagni (Rome)	MIL, CN	Sales Director
5	Epsilon	75'	Rome	MIL	Academy Director
6	Zeta	52'	Ancona	CN, MR	CEO
7	Eta	44'	Skype interview	VM	VP Business Innovation
8	Theta	55'	Barga (LU)	EF	Chief Medical Officer
9	Iota	41'	Rome	VM	Digital Area Managing Director
10	Kappa	53'	Skype interview	VM	Chief Technology & Innovation Officer
11	Lambda	58'	Milan	MR, EF	Director of Strategy and Business Development
12	Mi	18'	Crespellano (BO)	VM	Chief R&D - Manager engineering

Table 6. List of interviews

In the qualitative phase of the study, interviews were conducted to complement and integrate the findings from the survey, aiming to develop a deeper understanding of internal structural and contextual factors that might influence policies related to OI. The sample selection criteria included characteristics such as being recognized as national and international best practice bearers, being acknowledged as benchmarks for their innovativeness, and demonstrating the ability to achieve good financial performance despite economic challenges.

6.2. *Findings of the qualitative analysis*

The informants confirmed that all firms consider the role of human resources to be central, both at the individual and team levels. The external environment encompasses a wide range of factors, such as economic conditions, industry regulations, competition, emerging technologies, and market trends, which can create opportunities or challenges for firms, affecting their ability to innovate, grow, and compete in the marketplace.

It was determined that elements belonging to the two levels of context could have a positive or negative influence on a firm's openness and the possibility of implementing OI agreements. Table 7 presents quotes extracted from the interviews along with the labels used for coding.

Internal business enablers	"The fundamental investments that we have always tried to make and will continue to make are in people: training of people, creation of an inclusive culture and maintain a multicultural environment. This facilitated the creation of a team culture." (Interview 1) "What is important first of all is the firm's strategy must be clear, that is, the firm must know what it has to be and then it can change over time. So you need the strategy, you need leaders who can make it happen, the realisation is not just to have the idea or to support the right ideas, surround yourself with the people who can do it, motivate the whole team on the achievement of the results, because there is no better way to convince senior management to continue that strategy than by bringing results whether initial or minor." (Kedrion) "Participating in OI has always been in our DNA. Of course, we also built on internal knowledge and capabilities, because internal knowledge is necessary to screen external projects." (Interview 1)
Internal business obstacles	"This, for a workforce such as our firm, not entirely able to interact in native English, can sometimes create some complexities." (Mashfrog) "Possibly the other point is the speed with which you can get two interlocutors to align if you like, not necessarily when it comes to internal interlocutors are the start-ups and given the somewhat different mechanisms and dynamics, the DNA of the corporate and the DNA of the external player, even if the fastest player is not always the external one, sometimes we have also been the fastest of the external ones." (Electrolux) "Then talking about soft skills and cultural evolution, as you can imagine, people at first thinking about all there is to do on the business simply do not understand the fact that such changes can be the basis for doing everything else well. There was a time commitment that this required and certainly the support of people who came from outside and therefore also with very high expectations." (Domus)
External environmental enablers	"We (as Italians) surely have an advantage in the creativity, flexibility, and in the ability to transform difficulties into opportunities." (Interview 3) "Fondness for the firm is the only thing that saves us, the fact that we consider our firm as our home, makes us overcome the perennial difficulties. Find these two people, one 57 years old, the other 50 years old, who are in love with this firm of the territory and of Italy." (Aptar)

	"We are also part of a competence centre that help local institutions to foster exchange, dissemination and synergy, a very important topic Industry 4.0." (Electrolux)
External environmental obstacles	"Here (in Italy), we face the difficulty of collaborating with large universities because there is a strong competition. (...) Sometimes it is not possible to create an open dialogue because the context is particularly crowded, too bureaucratized, with interlocutors who are perhaps more attentive to other aspects than just the idea of building something together with a market partner." (Interview 10). "The difficulty I see is the world of venture capital, the Italian model is different and this is a bit of a constraint, the difficulty even of small and medium-sized firms, of start-ups to scale up, so when I say you have to compare yourself to the world because I look at the world so I compare the start-up in Catanzaro I compare it to one in Tel Aviv I compare it to one in Upsala I realise their difficulties such as the lack of tools so that I can, I start small from Italy and then I try to dig on a global scale." (Electrolux) "Research in Italy is very poorly supported, at an academic level very little, but also very little at an industrial level" (Kedrion)
Performance	"Our firm has historically always **grown** organically, even inorganically **through acquisitions**."(Aptar) "It is no coincidence that all the things done, all the **innovations**, all the **investments** made have **created two plants**." (Aptar) "Behind this, and especially in these two plants, is technology that has helped **minimise costs** and ensure a higher level of quality than was available on the market." (Aptar) "We did this with external collaborators because we obviously used external consultants, so they had specific expertise in the area however of **growth**." (Domus) "This strategy has paid off over the years and it pays off because in short the firm has been in the market for 40 years and is a leader with 70 per cent world m**arket share** in this sector."(Fantini) "These are all **costs** that you cut, and you don't even have to worry about obsolescence, management and safety, which is a major issue." (Vetrya)

Table 7. Findings of the qualitative analysis

7. Conclusion

This study is motivated by a practical concern about the mixed results of using Open Innovation as a collaborative strategy for technology management and performance. The study used data obtained in the field to reveal how factors internal and external to firms influence financial outcomes for those who adopt OI. Our research also provides insights into the various measures of OI that are found in the literature but have not been empirically matched to date. Showed that different type of OI measures (formal, within value chain and search depth) affects positively the financial performance in presence of pecuniary and non-pecuniary practices

fostering innovation, creating an innovation climate within the job place and being aware of the importance of the external environment.

Our study provides useful insights into the management of internal strategy for collaborative innovation. Specifically, (1) in order to establish an optimal method of OI, it is necessary to design human enablers such as a clear leadership role, collaborative climate, trust among employees, friendship, work on personality of team members to enable the creation of good working relationships; (2) external environmental factors must be considered relevant, especially the national environment and public policies to support innovation, but also the relevant competitive market must be monitored and in the consciousness of corporate actors.

There are several limitations to this study. First, the study examined only two industrial sectors from a single country. Although the work obtained fresh data on a fast-growing topic and just before a destabilizing shock such as the global pandemic, the results may not be generalizable to other sectors or countries. In addition, the study employed only one dependent variable as a performance measure. By conducting a quantitative analysis of the data on a larger sample by sector and departing from the use of the same questionnaire in future research, we intend to investigate the processes further by employing other classical methodologies such as OLS or Difference-in-Difference to provide a more robust quantitative description of the relationship between the independent and dependent variables.

8. Managerial implication

As a contribution to the professionals who will read this article, we can say that since reality is complex, it cannot be interpreted with standardizations and approximations by researchers. Based on formalizations crystallized in reports or papers, you cannot simply declare overnight to do Open Innovation without considering a great number of factors related to the internal and external context.

Therefore, a manager who intends to reap the benefits of Open Innovation must consider as fundamental the implementation of practices to sustain an innovative climate and stimulate employees toward exploration. The firm's external environment is crucial, and one must be able to manage influences of all kinds that may affect the firm's activities, seeking to make the best of each phenomenon, both positive and negative.

For future researchers addressing the topic, we can say that Open Innovation is confirmed to be a multifaceted paradigm as complex as reality and therefore cannot be interpreted with oversimplifications. The mediation of different factors and a multilevel analysis seem to be two key perspectives to understand the phenomenon. This opens new scenarios for future

research that will want to reconsider what has been said so far, applying methodologies and data that were not previously considered in the cause-effect relationship between OI and financial or technological performance.

In additional to internal firm practices to support innovation, the external environment also plays a crucial role in determining performance. Highly competitive sectors such as manufacturing and services in Italy are under pressure from competition at the national level, given the many excellences in the area. At the same time, it benefits from the many economic supports introduced in the last decade by the Ministry of Economic Development in the form of direct subsidies or tax credits. Depending on where the firm is headquartered, it can take advantage of an ecosystem scattered across the country to set up peer-to-peer collaborations or participate in system integrator value chains involving hundreds of partners for the realization of products and services. New regulations, such as the requirement to have an internal auditor, make it possible to explore new markets by growing through the highly qualified advice of audit firms that perform other activities such as strategic consulting.

This external condition drives firms to implement innovative project management and monitoring practices, encourage employees to experiment with new ideas through incentives, including pecuniary ones, and team management actions to express their creativity through a diverse composition and freedom of communication.

We conclude by emphasising that the mediation between the push from the external environment and the implementation of internal management practices, together with the implementation of Open Innovation, can enable the firm to achieve a positive outcome in terms of financial performance.

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Appendix

Fig. A

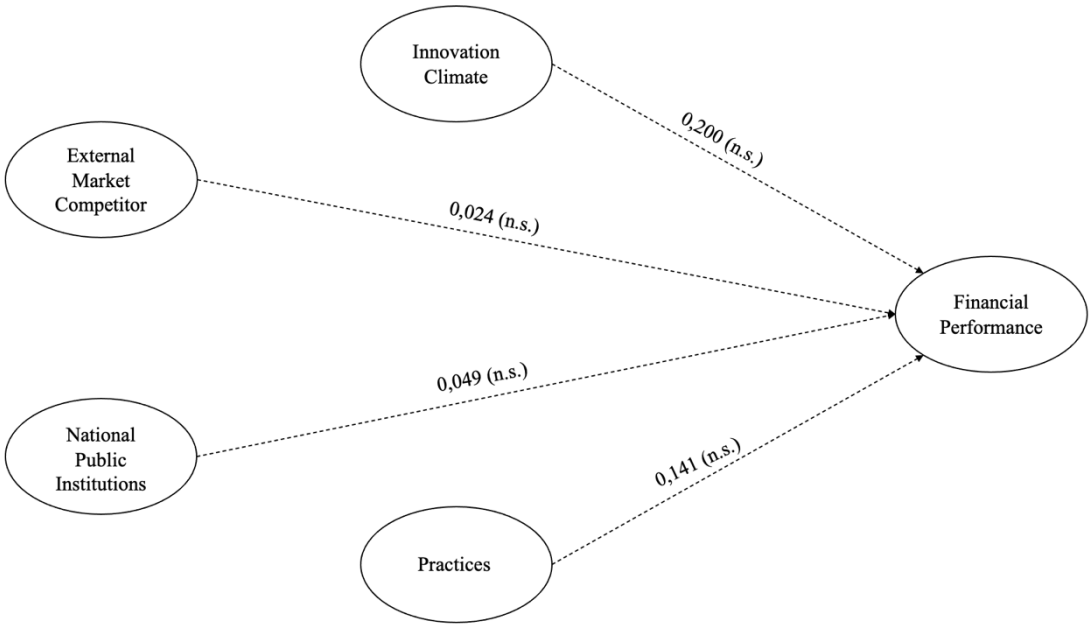
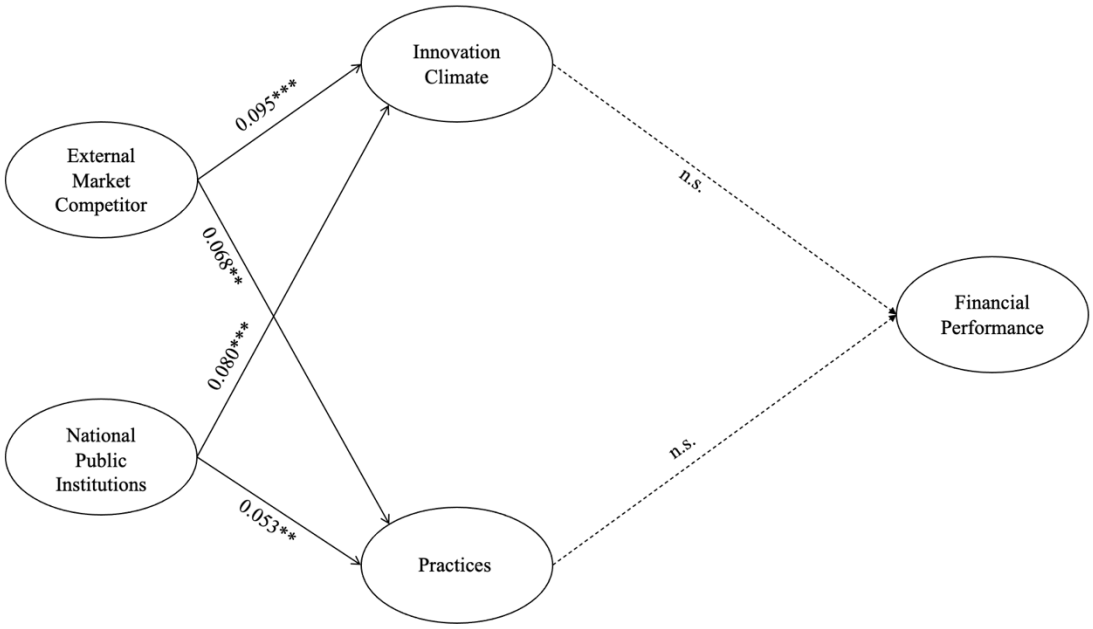


Fig. B



Chapter 2: Unlocking the benefits of Framework Programs in the area of ICTs: an analysis of the impact of participation on firms' intangible investment and business performance[2]

Abstract. This paper analyzes the impact of firms' participation in framework programs (FP) in the area of information and communication technologies (ICTs) on intangible investment, revenue and employment growth. It also examines how the heterogeneity of FP participants affects the outcomes of funded activities. The study uses a sample of firms that participated in framework programs and a control group of firms that did not participate. It is shown that firms that participate in framework programs in ICT related themes achieve greater growth in intangibles and achieve greater revenue and employment growth than firms that do not participate. It turns out that the heterogeneity of participants plays a significant role in determining the success of funded activities. Projects with diverse participants are more likely to succeed because they are better able to leverage the knowledge and skills of heterogenous pools of expertise to create innovative solutions. These findings have important implications for policymakers and companies seeking to improve their performance through participation in framework programs. By ensuring the diversity of FPs participants, these programs are likely to be more beneficial for companies' competitiveness and growth.

1.Introduction

The European Union's (EU) Framework Programmes (FP) for Research and Technology Development (RTD) are one of the major initiatives fostering knowledge creation and involving the cooperation of different actors including firms, universities and public research centres. Differently from other cooperative initiatives spontaneously originating from the decision of private or public agents, the FP consist in European public investments of relevant and increasing amounts of resources with the specific purpose of generating knowledge and contributing to knowledge diffusion, thus fostering competitiveness and growth.

While there is growing literature examining the impact of participation in EU Framework Programmes on knowledge transfers (Maggioni et al., 2007; Hoekman et al., 2013; Di Cagno et al., 2014) and on regional economic performance (Cassi et al. 2008; Arnold 2012; Muscio,

[2] This paper has been presented at the DRUID Conference 2023, NOVA School of Business and Economics

Rid and Rivera-Leon 2015; Di Cagno et al. 2021), the evidence on the impact of such initiatives on firms' performance is much more limited. Recently Mulier and Samarin (2021) evaluated the effect of the Horizon 2020 innovation funding program on firms' growth and innovative output. They found that subsidized firms were able to invest more in tangible and intangible assets, obtained higher growth of turnover and employment, and filed more patent applications. In this paper we extend this research in two directions. First, we select thematic project in the Information and Communication Technologies area to look at the complementarities between participation in such projects and firms' investment in intangible assets (Corrado et al., 2005). Second, we investigate the relationship between the characteristics of the network, namely the heterogeneity of participants, and firms' performance.

According to the empirical and theoretical literature (Miotti and Sachwald, 2003; Laursen and Salter, 2004; Bozeman et al. 2013; Becker, 2014) firms, universities and public research centres may draw benefits from their participation in knowledge partnerships, including access to complementary skills; direct access to scientific and/or technological knowledge; risk and cost sharing; reduction of the degree of uncertainty inherent in the cognitive process; opportunity to move towards the technological frontier; learning from other experiences through access to other institutions' best practices; particularly for businesses, the opportunity to internalise (part of) the spillovers. By looking at the role of FP participants' heterogeneity on firms' investment in intangible assets and performance, we shed direct evidence on the role and importance of such complementarities.

2. Literature review and research questions

Public knowledge partnerships (KPs) between companies, universities and research organisations, promoted by the public agent, established in order to create, share and disseminate knowledge, are a crucial aspect of the policies for research and technological development of the European Union since their introduction in the 1980s. This particular type of KP can be included, in the European context, among the tools through which to create the European Research Area, in which, by combining the resources of the member countries, it is possible to reach the critical mass necessary to face today's challenges posed by research science and technology (Luukkonen, 2000 and 2002; Hoekman et al. 2013).

Several scholars have highlighted how the (intentional) creation of knowledge originating from technological research and development activities is the basis of technological progress and this, in turn, of economic growth (Kline and Rosenberg, 1986; Jones, 1995 and 2005, Lundval, 2004). However, once knowledge has been created, to fully unfold its effects, it must spread

within an economy and between it and other economies (Jaffe et al. ., 1993, Coe and Helpman, 1995, Trajtenberg et al., 1997, Griffith et al., 2004 and Crespi and Geuna, 2008). KPs represent a potential channel for the dissemination of knowledge between various institutional subjects and, through these, between regions and countries (Di Cagno et al. 2014 and 2016).

From the point of view of the participants in the KPs, as highlighted by several authors (Etzkowitz and Leydesdorff, 2000; Miotti and Sachwald 2003; Laursen and Salter, 2004), the main benefits are linked to access to complementary skills; cost and risk sharing; the reduction of the degree of uncertainty intrinsic to the innovative process; the reduction of transaction costs in complex activities regulated by incomplete contracts; access to greater financial resources; for businesses, in particular, to allow the (partial) internalization of the spillovers that characterize the creation of new knowledge.

As already pointed out, the main policy tool that supports collaborative R&D in EU is the Framework Programme for Research and Technology Development (FP). This initiative, which began in 1984, has expanded and consolidated over time both in terms of available financial resources, number of participating organizations (companies, universities and research centres) and funded key areas/thematic areas, characterizing itself as one of the largest transnational efforts worldwide with the aim of stimulating research collaborations and dissemination of knowledge (Balland et al. 2019 and Kim and Yoo, 2019). The rationale behind this EU policy of public support for R&D activities is usually expressed either in terms of market failures related to the difficulty of companies to appropriate R&D returns, and/or in terms of strategies aimed at developing certain sectors, technologies or locations. In both cases, the intermediate objective is to stimulate the innovative capacity of the private sector which should then lead to improvements in company performance and also, in the long term, positive effects in terms of competitiveness and economic growth. (Klette et al. 2000, Vanino et al. 2019). One of the main initiatives through which public support for R&D can stimulate the innovative capacity of companies is to encourage collaboration with external subjects such as universities and research centres, thus helping companies to access new or pre-existing knowledge and skills which are otherwise inaccessible (Veugelers and Cassiman, 2005, Scandurra, 2016). This aspect is reinforced by the supranational dimension of the FPs and by the substantial involvement of the participants: the projects are promoted by self-organized consortia composed of various partners from different countries and a co-financing of the R&D in the project is required through the private funds of the partners of the same consortia (Roediger-Schluga & Barber, 2006).

A limited number of studies have analyzed the effects of participation in FPs research joint projects (RJPs) on company performance, using different methodologies and data, with heterogeneous results: no clear effects (Benfratello and Sembenelli, 2002), only indirect (Barajas et al., 2012) and direct and positive (Barajas et al. 2016, Aguiar and Gagnepain, 2017, Katay et al. 2019 and Mulier and Samarin, 2021).

Benfratello and Sembenelli (2002), selecting RJPs with at least one participating manufacturing firm from FP3 and FP4 over the period 1992-1996, use statistical tests against three performance variables (labor productivity, total factor productivity and price cost margin) to assess effects of the participation of these companies over time. They find out which companies they participate in RJPs under the EU-FP scheme show no significant change in performance. Barajas et al. (2012) based on a dataset with information on Spanish participants in research joint ventures supported by the EU Framework Program during the period 1995-2005 find that R&D cooperation has a positive impact on the technological capacity of firms, captured through intangible assets. The authors find also evidence that the technological capacity of firms is positively correlated with their labor productivity, thus confirming an indirect positive effect of participation in RJPs. In a subsequent work, the same authors, Barajas et al. (2016), focus on the effects of participation on the performance of small and medium-sized enterprises (SMEs) considering two dimensions: technological and economic results using information on Spanish participants in consortia supported by the specific measures for SMEs of the Sixth Framework Programme. Empirical evidence confirms a direct and positive impact on participants' technological resources. In terms of economic indicators, EBITDA per employee and labor productivity are positively influenced by the improvement of the technological background. All these effects are effective three years after the end of the project, confirming that SMEs are involved in market-oriented R&D projects. Also in the subsequent work by Aguiar and Gagnepain (2017), the authors find that the impact on the competitiveness of firms is significant, analysing the industry-oriented research joint ventures supported by the European Fifth Framework Program between 1998 and 2002. Results of the analysis suggest that participation in research projects can increase labor productivity by at least 44.4% while having a minimal effect on profit margin. Also the paper of Katay et al. (2019) assesses the impact of FPs funds for research and innovation on profit-oriented firms' productivity using a large dataset on both successful and unsuccessful applicants to the EU's 7th Framework Programme (30,984 firms from 46 countries) and balance-sheet data, with a Fuzzy Regression Discontinuity Design (FRD) technique, showing that the EU funds have had a positive impact on firms' post-treatment labour productivity. Mulier and Samarin (2021), using a difference-

in-differences (DiDs) estimation, evaluated the effect of the Horizon 2020 innovation funding program on firms' growth and innovative output. They found that subsidized firms were able to invest more in tangible and intangible assets, obtained higher growth of turnover and employment, and filed more patent applications.

A key factor that can determine the performance of companies participating in RJVs is collaboration with external parties. The heterogeneity of the participants is one of the salient characteristics of the FPs. This aspect reflects what is a more general trend observed in every field of scientific and technical research, which has attracted the attention of researchers and policy makers (Belderbos et al. (2004), Bozeman et al., 2013, Acebo et al. 2021).

In the article by Fabrizi et al. (2016) observing the effect of multisectoral international cooperation in R&D projects promoted within the framework of FPs on knowledge creation (new patents) in a sample of European countries, the authors highlight that all institutional sectors benefit from participation in these projects, with a greater impact for universities and public research centers than that observed for private companies. Szücs (2018) evaluates the impact of the EU's Seventh Framework Programme on the innovation activities of subsidized firms, with a particular regard to industry–university partnerships. Using matching and DiD estimation, he finds a positive effect on a range of innovation indicators. The number of project participants in general and university participants in particular positively affect performance, suggesting knowledge spillovers between project members. Research centres, on the other hand, do not exert positive externalities.

From the outset, the FPs' approach has been multi-thematic: a plurality of technological fields and sectors have been progressively supported. Among these, the information and communication technology sector (ICT) represents one of those of greatest attention: the diffusion of ICT and above all the stimulation of research through collaborative projects is a fundamental priority for the EU (European Commission 2009). This is due to the fact that the ICT sector is a technology sector of particular relevance due to its character of technologies of general use: speed of technological change, pervasive nature and potential to stimulate innovation throughout the economy (Bresnahan and Trajtenberg 1995). At an empirical level, this specific area was investigated only with respect to the effects of ICT RJVs in PF7 on regional total factor productivity (Vicente et al. 2019), but not with respect to the economic effects of the participating firms, with the exception of the article Aguiar and Gagnepain (2017). They select RJPs of FP5's User-Friendly Information Society (IST) programme, which falls under the broader ICT sector. As pointed out by the authors, the choice of these projects is by their industry-oriented nature: these projects are most likely to be driven by commercial

exploitation reasons rather than exploring a given technology, thus being able to have a clearer and more direct economic effect on participating firms.

The results presented so far regarding the empirical evidence on the impact of the Framework Programme indicate that its main contribution to the participating sector is related to the improvement of scientific and technological capabilities rather than directly to the economic performance of companies. Moreover, it appears that some characteristics of the network, particularly its composition, matter for reaping the benefits of firms' participation. Starting from this evidence, we intend to investigate the impact of participation in FP and of FP characteristics on firms focussing on the area of ICTs which is strategic for the long run performance. We are particularly interested to study the extent to which participation in FPs and the heterogeneity of FPs affect firms' decisions to invest in intangible assets, a strategic resource for managing the digital transition. In particular, focussing on ICT related FPs, we ask the following questions: Does participation in framework programs enable firms to grow in intangibles, turnover and employment? Does the characteristics of the FP networks in which firms are involved matter for reaping benefits from such participation? Does the composition of the network, and in particular, the heterogeneity of participant institutions matter?

To address these questions, we merge information on Horizon 2020 grant beneficiaries from CORDIS with their financial data obtained from Orbis-Europe. As we solely examine companies that have received innovation grants, there is a potential risk of selection bias. To alleviate this identification issue, we employ propensity score matching to generate a matched sample of comparable companies that did not receive grants. The ultimate dataset consists of more than 5,000 observations of firm-year, encompassing an equivalent number of grant recipient and control companies. The data is observed from three years prior to five years after the participating companies received an innovation fund.

3. Empirical strategy

Horizon 2020 was the EU's research and innovation funding programme from 2014-2020 (or FP8) , with a budget of around 80 billion euros, with over 30,000 projects signed and 36,039 entities involved (European Commission, 2020), focusing on three main key areas (or pillars): Excellent Science, Industrial Leadership and Societal Challenges, with respectively allocated resources of €24 billion, €17 billion and €30 billion. As stated by European Commission (2014, pp. 9-10), within the key area of 'Industrial leadership' falls support of "ground-breaking technologies needed to underpin innovation across all sectors, including information and communication technology (ICT)"…"Key enabling technologies such as advanced

manufacturing and materials, biotechnology and nanotechnologies, are at the heart of game-changing products: smart phones, high performance batteries, light vehicles, nanomedicines, smart textiles and many more besides" (see also Evangelista et al. 2018).

To test the relation among the participation to FP programs and the effects on firms' performance, we exploit the CORDIS database provided by the European Commission, which collects all the information related to the FP and Horizon 2020 (H2020) programs. FPs are divided into thematic areas that can be associated with industrial sectors, disciplinary scientific areas, or EU growth objectives such as job creation and removing barriers to innovation. In H2020 there are 79 different areas of investments, for a total of 37,885 cross-cutting projects. Since 2013, the EU has allocated about 80 billion euros to the participants of the H2020 programs, and the one with the highest number of funded projects is ICTs, which is among the priorities and pillars of the EU strategy. Table 1 shows how 16% of the total funded projects refer to this theme, and overall, over 60% of the total projects concern the top ten thematic areas.

Table 1: Thematic areas of FPs

Programme	Share
Information and Communication Technologies	17%
Specific Programme "People"	12%
Health	8%
Nanosciences, nanotechnologies, materials and new production technologies	5%
Transport(including Aeronautics)	4%
Specific programme: "Ideas"	4%
Food, agriculture and fisheries, and biotechnology	4%
Environment (including Climate Change)	3%
Joint Technology Initiative	3%
Research Infrastructures	3%
Research for the benefit of SMEs	3%
MSCA Mobility	2%

Source: Authors' elaboration based on CORDIS data

Among the EU-27 countries, we focus our attention on the most financed ones: Germany, Spain, Italy, France, and the United Kingdom. As shown by Table 2, these five countries cover almost the 60% of the 1552 H2020 programs.

Table 2. Distribution of H2020 investments among EU-27 countries.

Countries	Share
Deutschland	15%

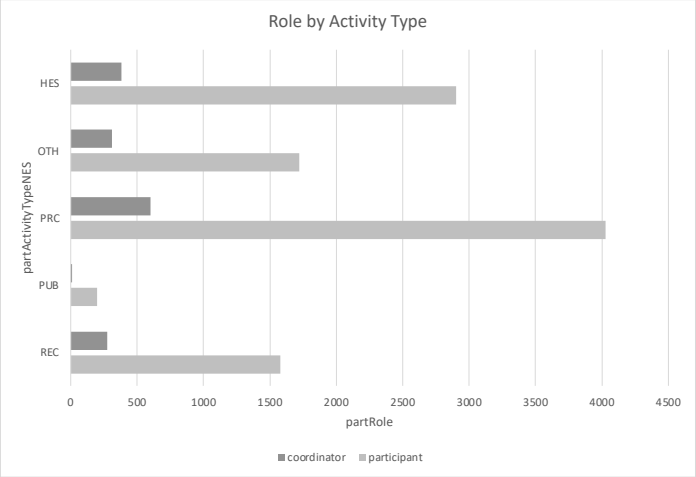
España	12%
Italia	10%
France	10%
United Kingdom	9%
Nederland	6%
Ελλάδα	5%
Belgique/België	4%
Österreich	4%
Suomi/Finland	3%

Source: Authors' elaboration on CORDIS data.

Each H2020 program give birth to a network of actors that might include five types of organizations, which are private for-profit entities (PRC), research organisations (REC), higher or secondary education establishments (HES), public bodies (PUB), and other organisations (OTH) which are note included among these categories.

PRCs constitute the majority of actors, indicating that the projects are mainly led by private companies, as can also be seen in the distribution of coordinators (represented by the darker bars in Figure 1) with respect to the other types of participant organisations.

Figure 1. Distribution of organizations financed by H2020 programs by type.



Note: PRC - private for-profit entities; REC- research organisations; HES - higher or secondary education establishments; PUB - public bodies; OTH- other organisations.

Source: Authors' elaboration of CORDIS data.

From these data we select 475 PRCs that sign a H2020 in 2015. The number of companies and the selected year has been chosen to avoid loss of information in the empirical analysis. This latter is framed in two parts: in the first part we test whether participating to an H2020 has an economic effect on firm's productivity, by applying a DiD technique; in the second part, we

analyse which are more profitable network's characteristics for a firm when is included in a H2020 project.

3.1 DiD: variables and method

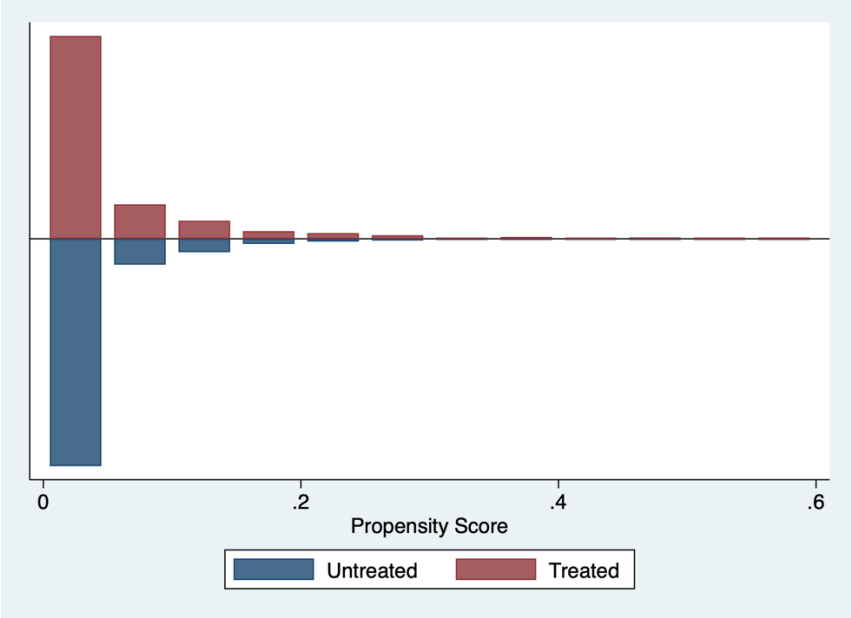
To test our first hypothesis , whether is profitable for a firm to belong to an H2020 project, we apply a DiD estimate. Profitability is computed by taking both assets and size variables, the former proxied by tangible and intangible assets, while the latter considering turnover and number of employees. These financial characteristics are extracted by merging our H2020 database with Orbis Bureau van Dijk data, which reports not only performance indicators, but also firm level information such as the geographical location and the industry classification, among the others. Geographical location, sector, and number of employees constitute the main variables to build our control group. This includes all the companies that never take part to an H2020 before or after 2015. We select the year 2015 to have financial information at least three years after and before the "treatment", i.e. joining an H2020. To select firms belonging to the control group we apply propensity score matching (PSM) (Rosenbaum and Rubin, 1983, Abadie and Imbens, 2006). Selection bias occurs when the characteristics of treatment-exposed subject differ significantly from the characteristics of unexposed subjects, causing potential confounding that can affect the results of the study. PSM is useful in these cases because it balances the characteristics of exposed and unexposed subjects, thus making the two groups more similar and reducing potential bias. The PSM operates by calculating the propensity score, which is the probability that an individual is exposed to the treatment based on his or her observed characteristics. This score is then used to select those individuals not exposed to the treatment who are most similar to those exposed, taken from the control group that is constructed using the characteristics of the organizations belonging to the treated group. In this way, the two groups are balanced according to their observed characteristics and fuzziness is reduced. In this case, the effect of public funding for ICT research projects is evaluated. If the winning organizations are very different from non-winning organizations, there may be confounding that makes it difficult to assess the effect of public funding. Using the PSM, one can calculate the propensity score for each organization and select the other non-exposed organizations that have a similar propensity score to the exposed ones. In this way, confounding can be reduced and more accurate estimates of the effect of public funding can be obtained.

We test the most appropriate matching with two different thresholds: 5 neighbours and 10 neighbours. The first value is more restrictive condition as it takes only the five more similar control firms with respect to the treated ones. The 10 neighbours' threshold relax this condition

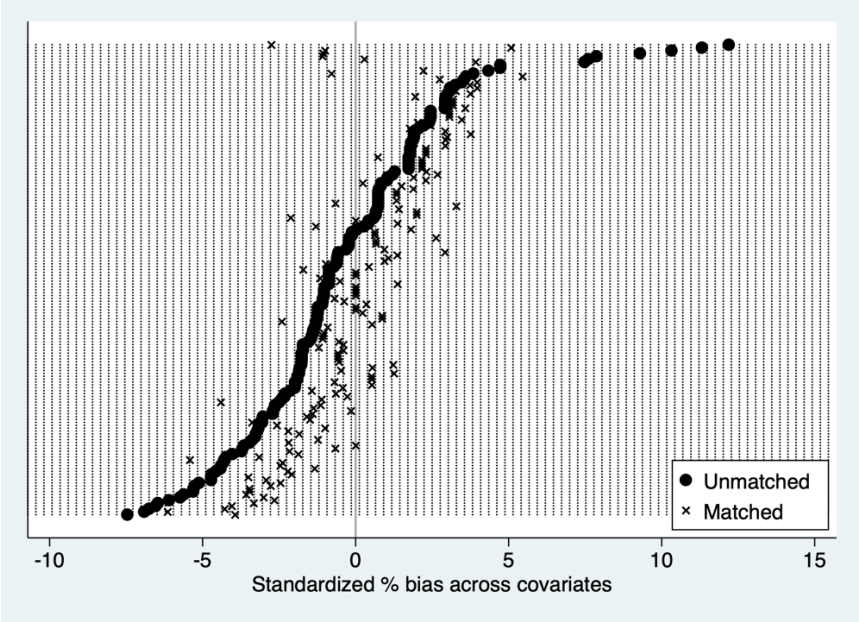
by taking the ten more similar (Caliendo and Kopening, 2008). For this reason, we prefer to rely on the 5 neighbours as our main control group. We also include in the model a caliper of 0.05, which excludes firms that are not sufficiently even if they fall in the group of the 10 nearest neighbours. Our PSM variables are sectors at NACE 2-digit level, provinces at NUTS3 level, and number the of employees in 2013, thus two years before the treatment. Results of the PSM are highlighted in Figure 3a, where the majority of the treated and untreated are evenly distributes, while Figure 3b shows that the variance between treated and control is close to the 0, thus proving the robustness of our control group.

Figure 3: (a) Distribution of treated and untreated observation; (b) Standardise % of variance across observations.

(a)



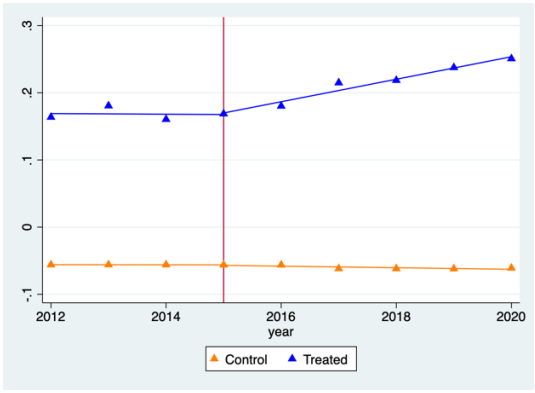
(b)



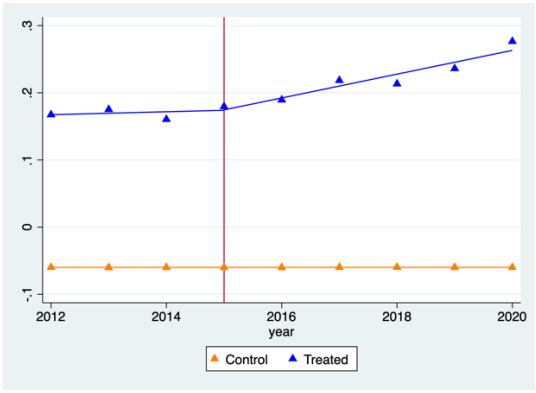
Before applying the DiD we must check for the presence of parallel trends before 2015 for the four dependent variables: (a) tangible assets, (b) intangible assets, (c) turnover, and (d) the number of employees. Figure 4 reports the trends of the treated and control firms before and after 2015.

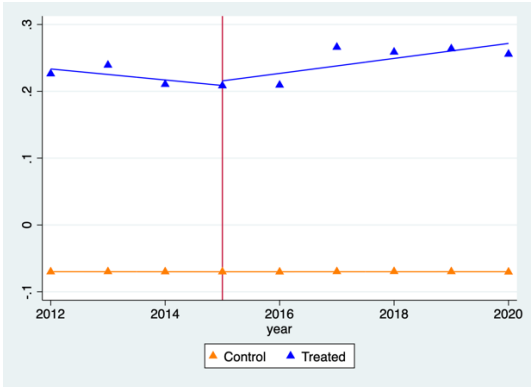
Figure 4. Performance trend for treated and control groups (treatment year: 2015): a. tangible assets; b. intangible assets; c. turnover; d. employment.

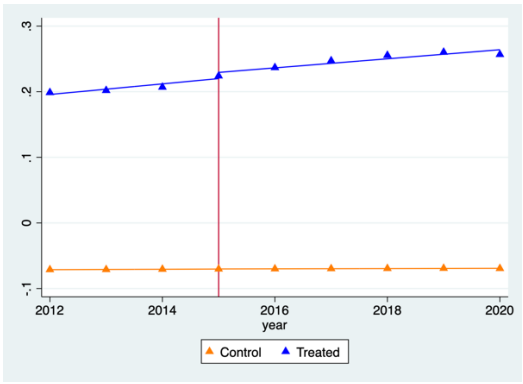
a.



b.



c. 

d. 

As it is possible to note, both treated and control have a similar trend in terms of performance, while those companies which take part to an H2020 programme show a significant improvement onward.

Thus, we can conclude that our control sample is representative of the treated companies.

We can then proceed to the DiD model, described by a panel random effects model as follows:

$$Y_{it} = \beta_0 + \beta_1 treat_{it} + \beta_2 time_t + \beta_3 treat_{it} * time_t + \beta_4 X_{it} + \alpha_i + \varphi_t + u_{it} \quad [1]$$

Where Y_itis the dependent variable measuring firm's performance in terms of tangible assets, intangible assets, turnover, and number of employees for a firm i at time t. 〖treat〗 _iis a dummy variable taking value 1 if the firm belongs to an H2020 project, 0 otherwise; 〖time〗 _tis a dummy variable taking value 1 for the year 2015 onwards, 0 otherwise, which constitutes the year when H2020 starts to take place in Europe; while the interaction between the treated and the year dummies constitutes the focal regressor in the DiD model. X_itis a vector of controls following Mulier and Samarin (2021). It includes: the share of total assets, the Herfindahl Hirschman index (HHI) for industry concentration in an area , and a dummy (rural) taking value 1 if the firms belongs to a rural area, 0 otherwise (ESPON, 2017). Finally, α_i and φ_tare geographical and year fixed effects, and u_itis the error term.

Table A.1 in the Appendix reports the summary statistics for the treated and control firms.

3.2 Network characteristics

The second part of our study aims to investigate which networking features affect the performance of firms that participate to H2020 projects.

Following previous studies on network characteristics and firm performance (Domenech et al., 2019; Taddeo et al., 2017; Bernard et al., 2022; Burlina, 2019; Huggins, 2001), we rely on a

set of indicators to test: (i) the role of the firm in the network; (ii) the size of the network; (iii) the composition of the network; (iv) the geographical dispersion; and, (v) the economic contribution of each firm in the network.

It is important to highlight that each firm might participate in the same period to different H2020 programs, thus all the variables are means of the indicators at firm level. As before we select those companies that are involved in an H2020 in 2015, thus all the indicators are referred to the same year.

The role of the organization (ROLE) indicates whether a firm plays the role of coordinator or participant in each research project. Values closer to 1 indicates that the company is in the most of the cases the coordinator of each project is involed.

Network size (N_SIZE) is based on the number of participants in the research group:

$$N\_SIZE_g = \sum_{i=1}^{N} participant_i$$

where g are the groups and I are the firms involved in each network. It takes a minimum value of 1, projects held by only one company, to a maximum of 111 participants, which is the case of the H2020 "Productive4.0" that aims to digitize European industry through a holistic approach focusing on digital automation, supply chain networks, and product lifecycle management. It seeks to enhance data transparency, consistency, and efficiency across various industrial sectors. (as shown in Figure A2 in the Appendix).

Following the type of organisations presented before (i.e. HES, OTH, PRC, PUB and REC), we define network composition to better understand the type of actors among the five that are included in the same H2020 project. If a network is composed by all the different actors, it can be considered highly heterogeneous; on the contrary, if it is composed by only one type of organisation, it is totally homogeneous. These can be considered two extreme cases. Values closer to 5 assume that a company, on average, participate to H2020 which includes mostly all the HES, OTH, PRC, PUB, and REC; on the contrary values closer to 1 call for networks where only few types of actors are represented.

Another element that is worth to investigate is the geographical location of each firm in the network. In fact, based on previous studies (Funk, 2014; Jenkins and Tallman, 2010; Glückler, 2007; Grieser et al., 2022), firms that are geographically proximate have higher performance returns thanks to knowledge spillovers and collaborations among partners located in the same

area. In this case the geographical dispersion takes place when firms involved in the project cooperate with firms from different provinces: the higher is the index, the more dispersed the network, thus more provinces appear in the project.

(f) Contribution. To obtain the economic contribution necessary for the implementation of the submitted project, participants will have to invest a portion of the total cost through their own resources, in the form of investment sharing ($invest\_share_i$).

$$invest\_share_g = \frac{invest\_share_i}{\sum_{i=1}^{N} invest\_share_i}$$

The contribution variable is then given by the mean value of the investment share at firm level. We rely on a set of OLS regressions where our dependent variables are the same of the DiD model, i.e. tangible assets, intangible assets, turnover, and number of employees. Our model is specified as follows:

$$Y_i = \beta_0 + \beta_1 role_i + \beta_2 size_i + \beta_3 composition_g + \beta_4 geo\_dispersion_g + \beta_5 contribution_g + \beta_6 Z_i + \varepsilon_i \quad [2]$$

The dependent variables are transformed in natural logarithm as well as the contribution variable to lower the variance. The vector Z_i includes industry and geographical fixed effects, while ε_i is the error term. In this case we consider the dependent variables at year 2019, while the other characteristics are computed for the period 2015. Unfortunately, some of the companies do not report the values of the four dependent variables for the year 2019, thus the number of observations reduces from 475 to 347. However, imposing a four-year lag between the dependent and independent variables mitigates for possible endogeneity issues such as reverse causality biases. Moreover, we perform a variance inflation factor (VIF) test to get rid of multicollinearity among our variables. Result of the test returns a mean value of 1.79 (and a maximum of 2.98) which is generally acceptable according to the rule of thumb of values below 10.

4. Main results

In the first research question, we asked whether participation in EU-funded framework programs enabled ICT firms to increase the value of intangible assets and achieve higher revenue and employment growth.

Table 3 presents the results of a statistical analysis conducted on data from a sample of companies that examined the effect of participation in framework programs on firm performance, based on the samples created using PSM with 5 nearest neighbours. The results indicate that participation in framework programs has a positive effect on investment in intangible assets ("Intangible Ass" variable) and employment growth ("Employment" variable) while it has a negative effect on company turnover ("Turnover" variable) and is not significant for investment growth in tangible assets ("Tangible" variable). This might indicate that participation in these programs make firm more willing to invest in their long run competitiveness rather than focussing on short term performance.

Tab. 3 The effect of FP participation on the growth of Tangible, Intangible, Employment and Turnover

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Tangible	Intangible Ass	Turnover	Employment	Tangible	Intangible Ass	Turnover	Employment
inter	0.047**	0.051***	0.018	0.042**	0.047**	0.051***	0.018	0.042**
	[0.021]	[0.019]	[0.013]	[0.018]	[0.021]	[0.019]	[0.013]	[0.018]
treat	0.223***	0.226**	0.294***	0.272***	0.172**	0.199**	0.273***	0.256***
	[0.081]	[0.090]	[0.091]	[0.084]	[0.075]	[0.084]	[0.087]	[0.081]
time	0.006	0.014***	0.002	0.005***	-0.006	0.007**	-0.002	0.002
	[0.007]	[0.005]	[0.002]	[0.002]	[0.010]	[0.003]	[0.002]	[0.002]
ln_tot_ass					0.019**	0.010***	0.007***	0.006***
					[0.009]	[0.003]	[0.002]	[0.002]
hhi2					0.001	0.000*	0.000*	0.000
					[0.000]	[0.000]	[0.000]	[0.000]
rural					-0.046**	-0.051***	-0.060***	-0.060***
					[0.019]	[0.020]	[0.021]	[0.021]
Constant	-0.057***	-0.060***	-0.070***	-0.072***	-0.193***	-0.133***	-0.121***	-0.111***
	[0.006]	[0.005]	[0.002]	[0.004]	[0.058]	[0.021]	[0.012]	[0.011]
Observations	18,266	18,266	18,266	18,266	18,266	18,266	18,266	18,266
R-squared	0.0116	0.0122	0.0166	0.0164	0.0362	0.0249	0.0263	0.0239
Number of ID	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070
Industry F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Regional NUTS3 F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Year F.E.	YES	YES	YES	YES	YES	YES	YES	YES

Note. Clustered standard errors at firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.10

Results are reported in Table 4. The results show that what matters for obtaining increases in intangible investment, employees and turnover from FP participation is not being part of large networks (the size of the network is either non-significant or negative) but to be part of heterogenous networks where firms collaborate with diverse partners including universities and research centers.

Tab. 4 The effect of research group characteristics on our dependent variables after treatment

	(1)	(2)	(3)	(4)
VARIABLES	Tangible	Intangible	Turnover	Employees
coordinator	0.674	1.740	0.971	1.306*

	[1.171]	[1.341]	[0.845]	[0.759]
m_size	0.032	0.009	0.040*	0.034*
	[0.038]	[0.043]	[0.022]	[0.019]
network_composition	0.484	0.363	0.746**	0.556*
	[0.471]	[0.508]	[0.360]	[0.295]
geo_dispersion	-0.009	0.045	-0.127	-0.059
	[0.219]	[0.255]	[0.133]	[0.110]
ln_contr	0.581*	0.551	0.491**	0.438**
	[0.314]	[0.366]	[0.201]	[0.170]
Observations	347	347	347	347
R-squared	0.955	0.909	0.981	0.953
Industry dummies	YES	YES	YES	YES
Geographical dummies	YES	YES	YES	YES

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Observations	328	328	347	347
R-squared	0.955	0.909	0.981	0.953
Industry dummies	YES	YES	YES	YES
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Note. Clustered standard errors at firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.10

5. Conclusion

The aim of this article is to examine how research and development collaboration impacts economic performance and how the heterogeneity of the participating group affects the expected outcome. The empirical analysis focuses on the R&D Joint Venture (RJV) supported by the European Union's Research Framework Program (FP), and more specifically on Italian, French, German, Spanish, and British companies that participated in it during the period 2014-2019.

The results presented offer important insights into the effect of participation in framework programs on the financial performance of organizations and the characteristics of research teams to achieve a positive outcome. Findings suggest that organizations participating can achieve greater growth in intangible assets and have better employment outcomes. In further, the results indicate that research group size and invested contribution have a negative effect on turnover and employment, while heterogeneity has a positive effect on all dependent variables.

This suggests that for firms it is not important to participate in large networks or to contribute with large resources but it is important to collaborate in heterogenous networks including different institutions such as universities and public and private research centres. This result confirms the existence of important complementarities between the knowledge that comes from private companies and the knowledge typical of universities and research centres (OECD, 2002; Miotti and Sachwald 2003; Laursen and Salter, 2004, Jaumotte and Pain, 2005b; Bettina, 2014) and the fact that these actors may draw benefits from their participation in heterogeneous knowledge partnerships.

Overall, the results of this study provide important insights to policymakers and managers about factors that may influence the performance and characteristics of organizations. Policymakers and managers should pay special attention to the development and management of public research resources. These grants have a significant impact on the performance of organizations, which suggests that decision makers should consider policies to expand the budget available for these funds but also to make it more profitable by ensuring to promote heterogenous networks. In particular, they should promote policies to support diversity within research groups through criteria that assign scores related to these characteristics or by establishing a mandatory standard structure for the type of organizations that are eligible to apply for funding. The overarching objective is to foster increased collaboration between researchers and companies to facilitate the effective transfer of knowledge.

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Chapter 3: Relational ties influencing innovation models: interlocking directorates and isomorphism in board social networks[3]

Abstract. This paper draws on isomorphism theories to examine how open innovation (OI) models in organizations are affected by the similarity of the composition of their board members and network of advisors. We adopt a relational lens to explore board isomorphism as a dynamic process, which is intertwined with the broader context of a board's social network and is related to the innovation models of the organization. The study uses a mixed method approach: we first adopted semi-structured interviews and questionnaires to measure open innovation models of organizations; then, we used secondary data on board and advisor composition to explore commonalties between organizations in the field. The sample consists of approximately 500 Italian manufacturing firms with over 10 employees. We employed a dyadic approach and conducted logistic regressions to examine the influence of shared board members and advisors on the adoption of similar innovation models within a specific industry, using financial performance data obtained from balance sheets. The dependent variable represents the similarity in open innovation model within each dyad, distinguishing between collaborations inside and outside the value chain, while the independent variables consist of the networks of board members and advisors. Results demonstrate that interlocking directorates facilitate the transmission of knowledge and ideas, therefore affecting the exploration and adoption of innovative models. The paper also identifies the various types of isomorphism that exist and their implications for innovation. We discuss how isomorphism leverage innovation capabilities, and how the composition of organizational boards and external advisors is important for innovation models in the field.

1. Introduction

Past research has shown that OI[4] is an innovation model that firms can apply to increase performance, technological portfolio, and return (Faems, De Visser, Andries, & Van Looy, 2010; Spithoven, Vanhaverbeke, & Roijakkers, 2013; West, Salter, Vanhaverbeke &

[3] This paper has been presented at the Sunbelt Conference 2023, University of Portland US

[4] The term Open Innovation (OI) was introduced by H. Chesbrough et al. in 2003, indicating the tendency of firms to use knowledge and technologies existing outside their business and to grant external organizations the use of ideas and technology that they cannot or do not want to exploit. The idea of Chesbrough was the creation of a new paradigm to design the firm's innovative activity, to be opposed to the "closed innovation" model.

Chesbrough, 2014; Tsai, Cabrilo, Chou, Hu & Tang, 2022). The broad concept has multi-faceted nature that scholars have investigated from different points of views: (i) direction of knowledge flow; (ii). level of openness; (iii). pecuniary and non-pecuniary objectives (Gassman & Enkel, 2006; Laursen & Salter, 2006; Bogers & Chesbrought, 2014). Another stream of literature on OI builds measures based on the nature of the subjects with which a firm collaborate for an Open Innovation model (Ahn, Mortara, & Minshall, 2017), creating two main categories inside and outside value chain collaboration. The control of the strategic decision for innovation is a key factor for firms to achieve growth and deserve further consideration in literature.

Most of the previous literature on networks and OI dealt with the measures like coupled OI (Gassmann & Enkel, 2004), and ecosystems (Alam, Rooney, & Taylor, 2022; Ferreira, Fernandes, Veiga, & Dooley, 2023; Remneland Wikhamn & Styhre, 2023) but little attention has been paid to the characteristics of a network that could be influence the open innovation model. It is essential to shift focus toward factors affecting the adoption of OI models, examining how organizations within a field are exposed to other organizations regarding OI practices. Furthermore, the extent to which organizations are exposed to isomorphism in their decision to adopt OI models remains unclear and warrants further investigation.

The importance of a comprehensive investigation on external networks of an organization stems from their crucial influence on the organization's adoption and implementation of diverse open innovation activities.

The notion that the impact of top-level executives is significant has been widely researched and verified through empirical evidence, as evidenced by studies such as those conducted by Hambrick and Mason (1984), Bertrand and Schoar (2003), and Finkelstein, Hambrick, and Cannella (2009). They have established a strong correlation between various traits of top-level executives, including age, tenure, education, and functional background, and the adoption of different corporate policies. These policies encompass a broad spectrum of organizational aspects, including employee compensation, as demonstrated by the research conducted by Bastos and Monteiro (2011).

Several studies have explored the role of specific factors as moderators during the decision-making process. Hitt, Beamish, Jackson & Mathieu (2007) emphasizes the significance of multilevel research in management, illustrating how diverse factors at varying levels of analysis can serve as moderators in decision-making processes. However, there remains a conspicuous gap in examining the potential influences on inter-firm innovation models that connect Open Innovation and Networks theory.

The absence of information regarding controls is a significant deficiency, given that these mechanisms operate not only from the top-down but also from the bottom-up. Beyond the CEO, other top-level executives are equally crucial stakeholders who may possess a greater degree of concern for the organization's long-term growth and development. As a result, they can exert pressure on the CEO to adopt measures that are both wise and farsighted when acting in a conditional capacity (Acharya, Myers, & Rajan, 2011).

Building upon previous research, this paper delves into the realm of Open Innovation (OI), using isomorphism theory as a foundation. Firstly, we examine how the presence of shared managers across firms within an organizational field impacts OI models, an aspect studied by Ahn et al., (2017). Secondly, we identify a gap in the existing literature, which has yet to fully explore the complex mechanisms propelling OI patterns, including the influence of individuals on firm-level openness. This lack of comprehensive understanding impedes our ability to effectively manage and organize OI activities (Vanhaverbeke, Chesbrough, & West, 2014), a challenge we seek to address through our interdisciplinary research approach.

Thirdly, our research expands the understanding of the roles of managers and advisors in OI and corporate governance within a specific industry. We recognize the characteristically internal ownership structure of such firms, often supported by external figures such as financial auditors and boards of managers and explore the extent of their influence on OI decision-making.

In anticipation of our results, we integrate isomorphism, board interlock, and networks literature to scrutinize the impact of key individuals, particularly interlocking board managers, and their role in advancing OI activities. We echo the sentiments of Gassmann, Enkel and Chesbrough (2010), West & Gallagher (2006) and West et al. (2014) regarding the meticulous exploration of OI micro foundations in future research.

Our study provides a valuable addition to the research on Open Innovation and isomorphism, offering insights that could inform future discoveries related to internal corporate governance in other industrialized nations. By examining Italian firms operating in the manufacturing sector, we not only illuminate the current landscape but also set the stage for further exploration of this crucial area.

Given these considerations, our research aims to investigate the influence of shared managers and advisors on the adoption of Open Innovation models by firms. Specifically, our research question is: "*Do organizations led by the same managers or sharing the same advisors tend to adopt similar Open Innovation models?"* To answer this question, we will draw upon the concept of isomorphism, particularly the mechanisms of mimetic and normative isomorphism,

to examine how shared management and advisory roles across firms might promote a convergence in Open Innovation models. This inquiry will expand our understanding of the human side of Open Innovation and how inter-organizational relationships shape the adoption of Open Innovation models.

2. Theory and hypotheses

Despite the vast and comprehensive body of literature on Open Innovation, covering various aspects from its adoption to its implications for business performance (Chesbrough, 2006; Enkel, Gassmann, & Chesbrough, 2009), there remains a significant gap in understanding how organizations are influenced by others within their field when adopting Open Innovation models. Existing research in business organization and management strategies acknowledges the potential impact of external actors on firms' internal decision-making processes (Dahlander & Gann, 2010). Yet, empirical evidence surrounding the relational view and the decision-making spillover effects is surprisingly scarce (Granovetter, 1985; Gulati, 1998; Powell, Koput, & Smith-Doerr, 1996). Furthermore, the mechanisms and dynamics of this inter-organizational influence on Open Innovation models remain largely unexplored, calling for a more focused investigation into this aspect of the Open Innovation paradigm (West & Bogers, 2014).

Literature of organization theory show how the reasons for decisions made by organizations derive (upper echelons) from the vision and choices that managers elaborate (March & Simon, 1958; Hambrick & Mason, 1984). Furthermore, the presence of managers in the boards of several firms (board - interlocking directorates) could help explain the nature of business decisions (Mizruchi, 1983). Following analogical reasoning (Gavetti, Levinthal & Rivkin, 2005), what can lead a firm to a series of successful choices depends on the experience the manager has accumulated in similar contexts experienced in his previous roles.

Some of the strategies adopted by a firm to manage technology and develop innovations can be exploitation or exploration (Levinthal & March, 1993). In the case of exploration, managers may decide to adopt closed or open innovation model (Chesbrough, 2003). Most research on open innovation "still neglects the human side" (Gassmann et al., 2010), so "we still know little about how individuals taking on the role of open innovators draw on their networks to support them in this role" (West et al., 2014). The mechanisms that drive the adoption of these open innovation models among firms also seem to be unexplored. We have little understanding of how organizational decisions to adopt open innovation models are influenced by other actors

in the field and whether their networks support them in OI models (Gassmann et al., 2010; West et al., 2014; Pinarello, Trabucchi, Frattini & Manfredi Latilla, 2022).

In recent work, there has been growing interest in evaluating open innovation at a more micro level than the organization itself and the microfoundation of Open Innovation (Bertello, De Bernardi, Santoro & Quaglia, 2022; Xia, Tan, Cao & Li, 2023). Recent examples include Du, Leten, & Vanhaverbeke (2014) study of open innovation projects that underscores the distinct challenges and benefits of engaging with partners from science-based and market-based backgrounds in open innovation projects. The authors highlight the necessity of employing different management practices to handle the differing knowledge bases and goals of these two types of partners. They demonstrate that effective management of these partnerships can lead to successful open innovation projects.

Salter, Ter Wal, Criscuolo & Alexy (2015) study of individual-level openness and idea generation in R&D considered how individuals' openness to external knowledge sources affects their ideation performance. The authors argue that a higher degree of openness at the individual level can stimulate idea generation, contributing to the organization's innovative capacity. They also note that the effect of openness is contingent on the individual's role within the R&D process, suggesting that the influence of openness may be context dependent. Ahn et al.'s (2017) study on the role of CEO characteristics in facilitating open innovation in firms using a sample of Korean SMEs, showed that CEOs' characteristics, namely, positive attitude, entrepreneurial orientation, patience, and education, can play an important role in facilitating open innovation. The study suggests that understanding this alignment is crucial for firms seeking to capitalize on the benefits of open innovation, highlighting the human side of openness.

Most recently, Rangus et al. (2019) study of the relationship between leadership, openness and innovation performance showed how leadership influences tactics and employee openness affects innovation performance at the individual and team levels.

This paper aims to investigate how common board members and advisors expose organizations to similar viewpoints and cognitive interpretative framework, which in turn affect the similarity in the decisions regarding their open innovation model. We assume that employees are not always willing to collaborate with external partners, share knowledge and accept external contributions, as demonstrated in research on corporate syndromes (Katz & Allen, 1982; Tranekjer & Knudsen, 2012). Managers and advisors are key figures in deciding innovation models.

Finally, we refer to the literature on forms of homogenization of established organizational fields (Giddens, 1979) through the concept of isomorphism. It is recognized in the literature as a binding process that forces a unit to resemble other units facing the same set of environmental conditions (Hawley, 1968). Isomorphism in organizational behavior can be broadly categorized into two types: competitive and institutional (Meyer, 1979; Fennell 1980).

Competitive isomorphism refers to the process where organizations become increasingly alike due to market competition, as they respond to similar customer demands, regulatory requirements, or technological advancements. On the other hand, institutional isomorphism pertains to the alignment of organizational practices driven by pressures from the broader institutional environment, and in our paper, we focus on the latter. Hence, the term institutional isomorphism describes the tendency of organizations operating in the same field to adopt comparable structures, processes, and practices over an extended period, often in response to external forces such as legal requirements, regulatory frameworks, and cultural conventions. This phenomenon can result in a lack of variety and uniformity within a particular field or industry.

Within this framework, three primary mechanisms contribute to institutional isomorphic change: mimetic, normative, and coercive. Among the mechanisms through which institutional isomorphic change occurs we are interested in mimetic isomorphism, which arises from standard responses to uncertainty i.e. when an organization faces a problem with unclear solutions, this can produce a workable solution at little expense (Cyert, & March, 1963); and also to normative isomorphism, which is associated with professionalization i.e. the quest of members of an occupation to define the conditions and methods of their work and a legitimacy for their professional autonomy (Sarfatti Larson, 1977; Collins, 1979). Based on the theoretical assumptions mentioned so far, we believe that more firms with the same manager or advisor could adopt more similar models for innovation also based on the normative and mimetic isomorphism. Hence, this paper seeks to be part of the debate that considers the role of institutional effects in the implementation of OI (Tsai & Ahn, 2023).

The adoption of open innovation (OI) models has become an increasingly popular trend in the corporate world, with firms using external sources of innovation to improve their competitiveness and performance. However, despite the benefits of OI, not all firms have embraced this approach to innovation. This study aims to explore the factors that influence a firm's adoption of OI models. Specifically, we analyze the potential impact of shared management and consulting staff on the likelihood of a firm's adoption of OI. We hypothesize that firms with the same managers and consultants are more likely to adopt OI models than

those without such shared staff. Our hypotheses are based on the premise that shared management and consulting staff may lead to greater coordination and collaboration, which in turn may facilitate the adoption of OI models. By testing these hypotheses, this study seeks to contribute to the ongoing discussion on the determinants of OI adoption and to provide insights for firms seeking to improve their innovation capabilities.

H1. Organizations led by the same managers are more likely to adopt similar OI models.

H2. Organizations sharing the same external advisors are more likely to adopt similar OI models.

3. Methodology

The two hypotheses described above will be tested through a mixed methodology consisting of two phases. The first qualitative phase involves the identification of OI models based on the construction of OI indicators. Exploratory interviews are conducted to create a questionnaire to be submitted to a significant sample of firms in a specific industry (manufacturing). We built on the results of the questionnaires to identify OI indices and models of each sampled organization. Then, we gathered further information from secondary databases, specifically Bureau Van Dijk's Orbis. Orbis is a comprehensive, global database providing detailed information on both private and public companies worldwide. It contains extensive data on around 375 million companies, including financials, ownership structures, M&A deals, corporate structures, patents, ESG metrics, and more. In our study, we utilized Orbis to obtain the names of managers and advisors of each firm. This database provided us with essential information on the individuals in leadership roles within these companies. In addition, Orbis also helped us understand the broader network of connections these individuals may have within the industry, further informing our analysis. The second phase of analysis begins with the construction of the network of firms sharing managers and advisors. Attributive datasets are constructed to be associated with each network and finally the effect of networks and other control variables on firms' OI application is analysed.

3.1 Sample selection and data source

To build the dataset and answer our research question, we adopted an exploratory mixed-method approach (Creswell, 2003; Venkatesh, Brown & Bala, 2013; Creswell & Clark, 2017). We conducted a multiple case study methodology with an inductive approach that integrates theoretical concepts with empirical evidence. Through the qualitative interviews done with 12 firms based in Italy, we identified a list of key antecedents of open innovation for firms by

performing open coding with NVivo software (Ceci & Iubatti, 2012; Paulus, Lester & Dempster, 2014). Using this coding, we developed the questions for the questionnaire to be sent to a larger sample of firms, also integrating questions from the CIS (community innovation survey). Quantitative data collection and analysis was done by submitting the questionnaire to a representative sample of Italian firms in the manufacturing sector with more than 10 employees. The survey was conducted using the CATI (Computer-Assisted Telephone Interviewing) method, and the response rate was 31 percent.

The final sample consisted of about 500 firms, and with the responses from the questionnaire (22 questions and 99 items) we constructed open innovation indicators based on what has already been observed in existent literature (Laursen & Salter, 2006; Dahlander & Gann, 2010; Popa, Soto-Acosta & Martinez-Conesa, 2017; Ahn et al., 2017). In addition, we integrated the dataset with financial, control, manager and advisor list variables downloaded from the Aida Bureau Van Djik database.

The indicators of Open Innovation that were measured are value-chain collaboration and outside value chain collaboration. The former involves the organization collaborating with entities upstream and downstream of its production activity (suppliers and customers), while the latter encompasses collaborations established between the organization and entities outside the aforementioned categories (competitors, external consultants, universities, public and private research centers). Ahn et al. (2017) used CIS data on firm cooperation to construct these measures related to the nature of the actors with whom the firm collaborates for IO activities. The identity of individuals participating in innovative collaborations may be related to certain dynamics of the innovation process and the degree of innovation achieved.

Since our goal is to understand how manager and consultant ties may influence the decision on innovation model, our data are relational (Wasserman & Faust, 1994).

Some authors have shown how social networks are structural contributors to innovation. According to research, sparsely populated and low-density structures offer several advantages, including the ability to combine diverse information from multiple domains to generate novel ideas (Coleman, 1988; Burt, 1995; Burt, Kilduff & Tasselli, 2013), the ability to accommodate contingencies (Mizruchi & Stearns, 2001), and the ability to promote collective action and synchronization (Burt, 2004; Obstfeld, 2005). Networks can also facilitate the transmission of a person's trustworthiness and the confirmation of that reputation within the network (Ferrin, Bligh & Kohles, 2015).

Social network analysis (SNA) techniques have been applied to understand the role of certain networks in determining decisions about model implementation and to support understanding of the role of social relationships in individual or organizational choices.

In literature it is called *affiliation network* and could exist between different entities. An example is the board of directorates, also referred to as an interlocking directorate network, and refers to the connections established among firms when individuals from one organization's board of directors serve on the board of another organization. This interlocking relationship creates a network of connections among various organizations through their board members, facilitating the flow of information, resources, and influence across the network. These networks can have significant implications for corporate governance, decision-making, and the diffusion of business practices and innovations. The relationships formed in an affiliation network can impact the dynamics among organizations, fostering collaboration, enhancing trust, or potentially leading to anti-competitive behaviour. Examining these networks, Biggiero and Magnuszewski (2023) show the interdependencies among firms, the roles of influential individuals, and the potential impact of these connections on organizational performance and industry trends.

Figure 1 shows the result when querying the Orbis database to obtain the list of managers and advisors of each firm in the dataset. We performed all analyses using the UCINET 6.598 software package (Borgatti, Everett & Freeman, 2002). As the dotted line shows, the same manager may be within different firms.

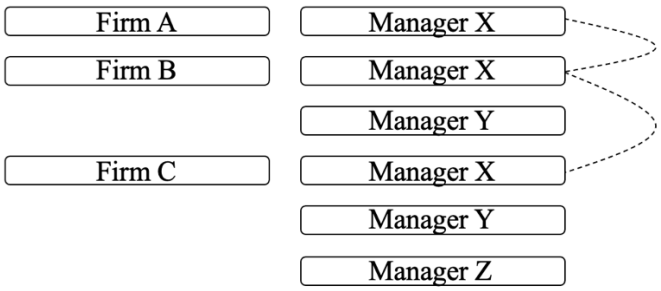

Figure 1: Example of data structure obtained through Orbis, authors' elaboration, 2023.

The next step is to transform the obtained list into a network. To do this, one must associate each manager with the firm in which he or she is located and obtain a list called an "edgelist." This is then uploaded to the Ucinet software, which transforms our two columns with the "person to event ties" control. The obtained 2-mode network (Figure 2) shows a network composed of two different types of nodes, the firms, and the managers.

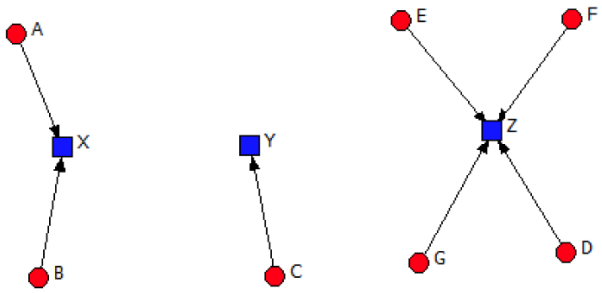

Figure 2: 2-mode network where X, Y and Z represent managers and A to G represent firms, authors' elaboration with the Ucinet software, 2023.

Last step is to convert the 2-mode network into a 1-mode network, in which the nodes are the organizations, and the links are built based on the co-membership of the same manager or advisor. The 2-mode network is entered as input dataset and output based on rows is requested. The output (Figure 3) generates only one type of node, firms, linked with others by links that are based on having the same person on their board.

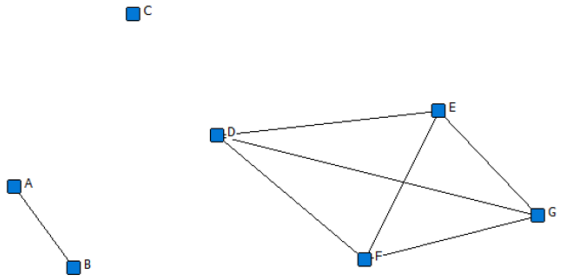

Figure 3: 1-mode network where A to G represent firms linked by managers, authors' elaboration with the Ucinet software, 2023.

Having built the networks (Figure 4) the dataset is complete along with the Open Innovation variables and some performance, geographic, size and innovation controls.

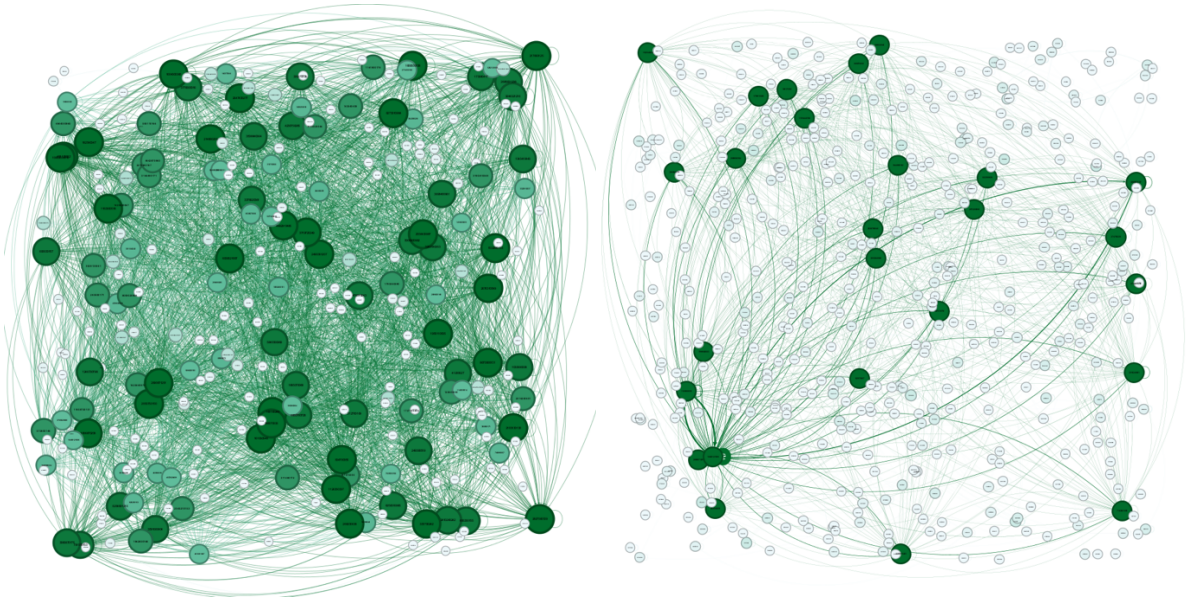

Figure 4: Advisor (left) and Manager (right) networks, authors' elaboration with the Gephi[5] software, 2023.

The last manipulation performed is "Matrix to Vector," which allows converting an adjacency matrix, representing a social network, into an adjacency vector, containing information about the links between nodes in the network. This command can be used in various contexts, such as the analysis of friendship networks, collaboration networks, citation networks or co-author networks. Converting the adjacency matrix into an adjacency vector allows for a more compact and manipulatable representation of the structure of the social network, enabling the relationships between nodes to be analysed more efficiently and accurately. In addition, converting the matrix into a vector simplifies the calculation of centrality metrics and other network properties, allowing the identification of the most important and influential nodes in the social network.

3.2 Measurement

3.2.1 Dependent variables

"Outside value chain collaboration/Within value chain collaboration" (Ahn et al., 2017). The dependent variable in our study describes the similarity in the nature of the subject with which the firm collaborate for open innovation activity and that occurs in each dyad. It describes in the first case whether the firms collaborate with entities that are upstream and downstream of its production activity (suppliers and customers), while the second case includes all those

[5] Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: An Open Source Software for Exploring and Manipulating Networks. International AAAI Conference on Weblogs and Social Media.

collaborations that are established between the firms and entities that are outside the previous categories (competing firms, external consultants, public and private universities and research centers, other third parties) assuming a value of "1" when the firms stated that it was implementing this Open Innovation model and a value of "0" otherwise.

3.2.2 Independent variables

As seen above, the transformation process to create a 2-mode network and then convert it into a 1-mode network, helped us build our main independent variables which consist of the networks of managers and consultants. Essentially, these networks represent the structure of relationships among the companies, based on the shared managers or advisors. To construct these networks, we used to identify data such as the VAT numbers of the companies, extracted the names of current managers and consultants from Aida, a proprietary data database by Bureau Van Dijk, and subsequently created adjacency matrices.

They are considered independent because they are thought to exert an influence on the dependent variable, which is the firm's adoption of open innovation models. The logic underlying the use of these networks as independent variables is the assumption that firms with shared managers or consultants are likely to be influenced by similar strategic decisions, perspectives, and experiences. This shared influence, represented by the networks, could then affect the firm's propensity to adopt similar open innovation models, thus serving as a potential determinant of the dependent variable.

3.2.3 Explanatory variables

Control variables are included to rule out the potential influence that other factors might have on dependent variables. Our sample using continuous variables with a matrix describing the absolute difference in (financial performance, publications, and intangible assets) between the pair of actors in each dyad. The continuous variables, which are numeric variables that can take any value within a certain range, including any value between two numbers. In this study, the continuous variables describe the absolute difference in three aspects: financial performance, publications, and intangible assets, between two organizations (a dyad). For instance, if one organization in the dyad has a financial performance of 100 and the other has a performance of 80, the value of this continuous variable for the dyad would be the absolute difference between these two numbers, i.e., 20. The same calculation is made for publications and intangible assets.

Then, we have categorical variables that have value "1" if the organizations belong to the same (region, industry, size). These are variables that can be divided into several categories but have no order or priority. In this study, the categorical variables have a binary form, meaning they can take one of two values: "0" or "1". The value "1" is assigned to a dyad if the two organizations belong to the same category in terms of region, industry, or size. For example, if two organizations are from the same region, the variable "region" for this dyad would be "1". If they are from different regions, the variable would be "0". The same applies to industry and size.

This approach allows for a nuanced analysis of the differences and similarities between pairs of organizations and how these characteristics might influence their adoption of Open Innovation models.

	Outside Valuechain Collaboration	Within Valuechain Collaboration	Advisors Networks	Managers Network	ROE	Region	Industry	Dimension	Intangibles	Publications
Observations	500	500	73500	2116500	486	500	500	500	488	500
Missing	0	0	0	0	14	0	0	0	12	0
Minimum	0	0	0	0	-147	1	1	1	0	0
Maximum	5	2	2	14	98	17	9	3	115853	1931
Sum	384	175	511	4415	5275	4798	1254	1041	1234975	13863
Average	0.768	0.349	0.006	0.002	10.85	9.6	3.1	2.1	2530.68	1.9

Table 1: Descriptive statistics of the original variables

Variable	N	Mean	Median	Std	Min	Max	Skewness	Kurtosis
Open Inn 1	249500	0.694	1	1698	0	1	-0.842	1709
Open Inn 2	249500	0.701	1	0.075	0	1	-0.881	1776
Advisor	249500	0.204	0	0.404	0	4	1.5	3382
Manager	249500	0.007	0	0.278	0	56	98943	15215.02
ROE	235710	19096	12	23213	0	245	2847	14014
Region	249500	0.167	0	0.373	0	1	1783	4179
Industry	249500	0.737	1	0.439	0	1	-1.08	2166
Dimension	249500	0.761	1	0.425	0	1	-1229	2511
Intangibles	249500	2.58	2	2065	0	12	0.981	3727
Publications	249500	1.83	2	1628	0	8	0.732	2929

Table 2: Descriptive statistics of the vectorized matrix

In the following table 3 are shown the variables used in the model, the typology, and the description.

Variable type	Variable name	Code	Description
Dependent variables	The preference for outside value chain OI	outvchaincoll	If the firm collaborate with entities that are upstream and downstream of its supply chain (suppliers and customers) , it takes 1, otherwise it takes 0
	The preference for inside value chain OI	vchaincoll	If the firm collaborate with entities that are established between the firms and entities that are outside supply chain (competitor, external consultants), it takes 1, otherwise it takes 0
Independent variables	Network of managers	man	Adjacency matrix where the match between the two firms is 0 if they have no managers in common, 1 otherwise
	Network of advisors	adv	Adjacency matrix where the match between the two firms is 0 if they have no advisors in common, 1 otherwise
Control variables	Return on Equity	ROE	Synthetic financial performance index of return on equity investment
	Geographical location NUTS2	reg	The geographical region in which the firm is headquartered
	NACE code sector	ind	The code of the industry to which the firm belongs
	Size of the firm	dim	Firms size based on the number of employees defined with three categories (1) < 50; (2) between 50 and 250; (3) > 250
	Intangible assets in financial statements	int	Economic value reported for intangible assets as a proxy for innovation
	Number of patent	pubb	Number of patents owned by the firm

Table 3: Main variables and definitions

4. Analysis of the results

The analysis is performed by applying logistic regression to see the relationship between the dependent variables, and the independent variables (networks). The purpose is to predict the probability of occurrence of the observed binary event (OI model).

The results (Table 4) display four analytical models, each representing a linear regression model that aims to explain the variation in the dependent variable, Open Innovation, through

several independent variables and control factors. We used a stepwise approach in model building. The first model describes only the effect of the control variables.

The second and third model show that the independent variables considered separately – advisor and manager - are significantly associated with the dependent variable. The control variable industry has the highest coefficient, suggesting that this factor still has the greatest impact as control. The pseudo-r square value is slightly higher in the third model than in the second, indicating that the independent variables considered have a slightly greater ability to explain the variations in the dependent variable.

Overall, the results of this analysis suggest that the independent variables considered are significant and have an association with the adoption of the same OI model. However, again, with a pseudo-r square value of only 0.024, and 0.035 their overall effect is small and only a small part of the variance in the dependent variable is explained by the independent variables considered.

The fourth model makes together the independent variables manager (manager interlock) and advisor (shared advisors) and confirm again a positive and significant relationship with the dependent variable, indicating that the higher the percentage of manager and advisor, the higher the Open Innovation model. Only for managers is the effect slightly reduced.

It was also observed the coefficient "c.man#c.adv" that is not reported in the table but is not significant, indicating that there is no significant interaction between the "man" and "adv" variables. The model has an R-squared of 0.036, indicating that the independent variables explain only a small part of the variation in the dependent variable. However, the model has a high degree of statistical significance ($p < 0.001$) and a high F-test value (858.710), indicating that the model has a good fit to the data. This overall supports our research hypotheses.

All models show that, among the control variables, the financial performance and innovation variables have a weakly negative and significant effect. The variables "size" (firm size), "region" (region in which the firm is located) and "sector" (sector in which the firm operates) have a positive and significant relationship with the dependent variable, indicating that the larger the size of the firm, the region in which it is located and the sector in which the firm operates, the greater the possibility for the firm to apply the OI model.

	Model 1	**Model 2**	**Model 3**	**Model 4**
Network Variables				

Managers Network		0.089***		0.085***
		(0.000)		(0.000)
Advisor Network			0.438***	0.438***
			(0.000)	(0.000)
Exploratory Variables				
ROE	-0.004***	-0.004***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Region	0.125***	0.123***	0.130***	0.130***
	(0.000)	(0.000)	(0.000)	(0.000)
Industry	0.709***	0.710***	0.709***	0.710***
	(0.000)	(0.000)	(0.000)	(0.000)
Dimension	0.245***	0.245***	0.229***	0.229***
	(0.000)	(0.000)	(0.000)	(0.000)
Intangibles	-0.022***	-0.022***	-0.017***	-0.017***
	(0.000)	(0.000)	(0.000)	(0.000)
Publications	-0.015***	-0.015***	-0.012***	-0.012***
	(0.000)	(0.000)	(0.000)	(0.000)
# Observations	235710	235710	235710	235710
Cragg & Uhler's R2	0.041	0.041	0.049	0.049
McFadden's Adj R2	0.024	0.024	0.029	0.029
R-squared value	0.024	0.024	0.035	0.035

Table 4: Panel logit regression results

5. Discussion

Delving into the realm of corporate networks, this paper illuminates the critical role of board members and shared advisors in shaping innovation models, simultaneously highlighting the hurdles that firm owners encounter due to existing governance frameworks.

This paper brings a significant theoretical contribution to our understanding of how firms adopt Open Innovation models. The study uncovers the important role that board composition and advisory networks play in the transition from a closed to a more participatory innovation process. The influence of interlocking managers and shared advisors is especially highlighted, as firms with a high percentage of these actors are found to adopt Open Innovation models more readily.

Moreover, the research delves into the dynamics of the 'human side' of Open Innovation. It provides valuable insights into how the characteristics of firm size, region, and sector can influence the adoption process. The study presents an in-depth analysis of the micro foundations of the managerial open innovation model, predominantly through the lens of network analysis techniques.

The theoretical contribution also extends to an exploration of isomorphism in organizational structures, processes, and practices. The research illuminates how mimetic isomorphism among managers and normative isomorphism among advisors can lead to homogeneity in the adoption of Open Innovation models across firms. Particularly, the Italian context of the study, which imposes stringent regulations for business advisors, bolsters the understanding of the role of professional autonomy and legitimacy in decision-making.

The practical implications of this paper are manifold, offering valuable guidance to firm owners, stakeholders, managers, and advisors.

Firstly, the study emphasizes the importance of carefully considering the composition of the board of directors and advisory network. A higher percentage of interlocking managers and shared advisors is linked to a positive impact on the adoption of Open Innovation models. Consequently, firms striving for a more participative model of innovation should pay close attention to these aspects of their governance structure.

Secondly, the results suggest that the firm size, region, and sector can significantly facilitate the adoption of Open Innovation models. These findings offer practical implications for strategic decision-making processes, especially for firms operating in industries and regions that are conducive to the adoption of such models.

Thirdly, the study highlights the influence of isomorphism, particularly mimetic and normative, on the decision-making process. In practical terms, this implies that managers might benefit from monitoring the strategies and decisions of their counterparts in similar organizations, while advisors should consider the professional norms and practices of their category. The study further suggests that in contexts where regulatory frameworks are stringent, as in Italy, firms should pay special attention to these norms and practices.

The research also underscores the importance of network analysis techniques in understanding the dynamics of Open Innovation adoption. In practice, this suggests that firms could potentially benefit from conducting or commissioning similar analyses, especially for exploring the social capital network of their own organization.

While the research provides valuable insights into the role of interlocking managers and shared advisors in the adoption of Open Innovation models, it does come with certain limitations.

The research is primarily based on a sample of Italian firms. As such, the results may not be directly applicable or generalizable to firms in other geographical locations or cultural contexts. This limitation can potentially affect the validity of the findings in different settings.

The study may suffer from omitted variable bias. This occurs when there are other variables, not included in the analysis, that are correlated with both the independent and dependent variables. Such omitted variables could potentially impact the accuracy of the results and their interpretation.

Future developments of this research could take several directions. They could expand the geographical scope to include firms from different countries or regions. This would increase the generalizability of the findings and provide a more comprehensive understanding of how governance structures affect the adoption of Open Innovation models globally.

In addition, future studies could incorporate additional variables that may influence the adoption of Open Innovation models. These could include factors like organizational culture, leadership style, technological capability, and more. This would reduce the risk of omitted variable bias and provide a more holistic view of the factors affecting the adoption of such models.

In conclusion, despite the identified limitations, this paper makes a significant contribution to the existing literature on the management of networks among firms, particularly focusing on the impact of board members and shared advisors on the innovation process. This research provides a nuanced understanding of the influence of governance structures on the adoption of Open Innovation models, underscoring the importance of the composition of the board of directors and advisory network in facilitating the adoption of these models.

Furthermore, the research provides robust evidence supporting the theory of institutional isomorphism in the context of firms' governance structures and innovation processes. The paper highlights how organizations operating in the same industry often adopt similar structures, processes, and practices in response to external forces such as legal requirements, regulatory frameworks, and cultural conventions. This results in an intriguing pattern of mimetic and normative isomorphism among managers and advisors, respectively.

Additionally, this study adds to the literature by providing an in-depth analysis of the human side of the Open Innovation phenomenon, illuminating the micro foundations of the managerial Open Innovation model. The use of network analysis techniques to generate this evidence opens new avenues for future research, including the potential for more detailed exploration of business case studies applying Open Innovation and the creation of social capital networks within firms.

The paper also emphasizes the need to consider context-specific factors in studying firms' innovation practices, given the complexity of reality and the diverse contexts in which firms operate. It underlines the importance of considering country and cultural factors (Chesbrough, Heaton & Mei, 2021) as well as the influence of local regulations on the practices and decisions of managers and advisors.

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Conclusions

The extant literature has explored the themes of Collaborative Innovation (CI) and financial performance in depth, although it has primarily emphasized their relationships with Open Innovation models and Research Joint Ventures. The present study advances these research fields by considering both the influence of the external environment and the characteristics of the involved actors on achieving financial and innovative performance.

The findings corroborate that the mere implementation of Open Innovation models and simple participation in research projects are on their own not sufficient to enhance the financial performance of companies. In fact, a superior financial performance is attained whenever the external context, such as the types of collaborators or market conditions, are taken into consideration. This is due to the increasing awareness of organizations of the importance of partner selection and symbiosis or contrast with external factors in creating a conducive environment for CI. Consequently, institutions in the context of RJVs tend to reward research groups that are more heterogeneous in terms of skills and nationalities.

On the other hand, this work illustrates that internal factors within an organization play a pivotal role, to the point of facilitating or hindering the commitment of an individual firm to implementing innovative models. Furthermore, the third chapter reveals there is a relationship between interlocking directors boards of companies and the management choice of which innovative models to implement. On the basis of such recurrences, companies can be influenced to the point of implementing the same strategies, a process that is also driven by the fact they belong to the same industry or are located in the same geographical area. These results demonstrate that although boards are committed to outlining strategic guidelines, they often accept subjective perspectives when implementing CI activities. Therefore, firms should consider these elements as conditions to promote or hinder certain strategic choices for the implementation of CI models.

From a methodological perspective, this thesis has utilized a mixed qualitative-quantitative approach that combines econometrics, social network analysis, structural equation modeling, interviews, and archival databases, together with secondary and primary data collected through questionnaires.

In conclusion, reference can be made to the title to outline the *Strategies for Effective Innovation Management*. The analysis suggests that CI, conceived as Open Innovation, is an effective model because it allows a better performance, net of certain internal and external conditions of the company, to be achieved. Similarly, Research Joint Networks also allow an

increase in employment and intangibles to be achieved, but even more so if certain criteria are observed when choosing one's research group partners.

However, this work also suggests, to companies, that certain dynamics related to managers' and advisors' experiences and knowledge might induce the board to make CI implementation choices that are not effective or suitable for the company, but simply for institutional or mimetic isomorphisms. Keeping in mind the importance of assessing the internal and external characteristics of a company is the first step toward defining what CI strategy to use to improve the financial and innovative performances of the company.