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From Single to Multi-Project Participation: SME Absorptive Capacity in Horizon 2020



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Loreta Isaraj

Direttore Elena Ragazzi

Direzione CNR-IRCrES
Istituto di Ricerca sulla Crescita Economica Sostenibile
Strada delle Cacce 73, 10135 Torino, Italy
Tel. +39 011 3977612
segreteria@ircres.cnr.it
www.ircres.cnr.it

Sede di Roma Via dei Taurini 19, 00185 Roma, Italy
Tel. +39 06 49937809 / Fax +39 06 49937808

Sede di Milano Via Corti 12, 20121 Milano, Italy
Tel. +39 02 23699501 / Fax +39 02 23699530

Sede di Genova Corso Ferdinando Maria Perrone 24, 16152 Genova, Italy
Tel. +39 010 6598798

Comitato Redazione

Grazia Biorci, Igor Benati, Antonella Emina, Serena Fabrizio, Lucio Morettini, Susanna Paleari, Anna Perin, Emanuela Reale, Secondo Rolfo, Andrea Orazio Spinello, Isabella Maria Zoppi.



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From Single to Multi-Project Participation: SME Absorptive Capacity in Horizon 2020

LORETA ISARAJ

CNR-IRCrES, Consiglio Nazionale delle Ricerche, Istituto di Ricerca sulla Crescita Economica Sostenibile, via dei Taurini 19, 00185 Roma, Italia

Corresponding author: loretaisaraj@cnr.it

ABSTRACT

This paper presents an analysis of SME participation in the European Framework Programme for Research and Innovation (Horizon 2020), focusing on the role of firm age in shaping funding engagement and success. Our dataset comprises a broad sample of Italian SMEs, allowing us to distinguish between firms participating in a single project and those engaging in multiple projects. We find it important to distinguish two patterns of participation: single engagement, where firms participate only once throughout the entire seven-year duration of Horizon 2020, and sustained involvement, where firms secure funding for multiple projects over time. Our econometric results indicate that older SMEs, benefiting from accumulated experience and established networks, tend to perform better in multi-project participation, achieving higher funding efficiency compared to younger SMEs. In contrast, younger SMEs, while more agile and innovative, often face challenges in sustaining long-term engagement due to resource constraints and limited administrative capacity. These findings underscore the importance of firm age as a key determinant of absorptive capacity and funding success in EU research programs, with implications for policies aimed at improving SME access to international R&D funding.

KEYWORDS: Horizon 2020, SMEs, age, absorptive capacity, multi-project engagement.

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1. INTRODUCTION

Understanding how firms leverage external knowledge to drive innovation is a key focus in the field of business and innovation studies. The concept of absorptive capacity, introduced by Cohen and Levinthal (1990), refers to a firm's ability to recognize the value of external knowledge, assimilate it, and apply it to commercial ends. This capability is particularly crucial for Small and Medium-sized Enterprises (SMEs), which often rely on external funding, collaboration, and R&D knowledge to overcome resource constraints and enhance their competitiveness. For SMEs, absorptive capacity translates into the ability to effectively leverage external resources – such as funding from national, regional, and international programs – to improve innovation performance, competitiveness, and sustainability (Spithoven et al., 2011). Firms with higher absorptive capacity tend to achieve better outcomes, including more successful implementation of R&D projects and higher financial returns per project.

Horizon 2020, the European Union's flagship policy for fostering innovation, provides a valuable framework for examining how SMEs leverage external resources to drive innovation. Launched with the aim of promoting cutting-edge industrial technologies, infrastructure, and human resource development, Horizon 2020 offers significant funding opportunities for diverse organizations, including SMEs, to engage in collaborative R&D initiatives (Kim & Yoo, 2019; Kalisz & Aluchna, 2012). However, despite the program's efforts to simplify participation and ensure fair access, structural inequalities in innovation capacity persist across Europe, as reflected in the *European Innovation Scoreboard*.

For Italian SMEs, which play a crucial role in the country's economy, accessing Horizon 2020 funding has been particularly challenging. Italy is classified as a Moderate Innovator and faces significant competition from nations with more developed R&D ecosystems (Murea, 2013; Puukka, 2018). While Italy increased its participation in Horizon 2020 compared to previous framework programs, its success rate for securing funding declined, reflecting the growing competition and barriers to effectively using these resources. This imbalance underscores the importance of examining how Italian SMEs navigate the complexities of Horizon 2020 and how their ability to leverage external resources affects their innovation performance.

The advantages of participating in Framework Programmes (FP) like Horizon 2020 are widely recognized. In most cases, the benefits of participation exceed the costs (Åström et al., 2012). Public funding for R&D and innovation tends to reduce the gap between private and social returns by balancing smaller private benefits with larger social benefits (Hanel, 2008). This type of financial support enhances firms' capacity to engage in R&D projects that they might not be able to undertake otherwise, thereby strengthening the broader innovation ecosystem and contributing to long-term economic growth and competitiveness.

Building on this foundation, this study explores how the ability of SMEs to leverage external funding manifests in their participation in Horizon 2020, with a particular focus on the dynamics of single versus multi-project engagement. Horizon 2020 was designed to provide equitable opportunities for SMEs across Europe; however, significant disparities persist in funding outcomes, particularly for Italian SMEs. These disparities stem from differences in firm-level characteristics, sectoral dynamics, and regional inequalities, highlighting the need for a deeper understanding of the factors driving funding success.

The disparities in funding outcomes among Italian SMEs suggest that firm-level characteristics play a critical role in determining funding efficiency. Among these characteristics, firm age emerges as a key determinant of innovation performance and the ability to manage project complexity. Older SMEs benefit from accumulated experience, established organizational routines, and stronger networks, which enable them to handle the administrative and operational challenges of securing and managing complex projects more effectively (Autio et al., 2000). In contrast, younger SMEs - despite their greater flexibility and innovative potential - often face structural disadvantages, such as limited organizational maturity and financial capacity, which

constrain their ability to sustain performance in multi-project settings (Sørensen & Stuart, 2000). Understanding how the relationship between firm age and funding efficiency evolves across different levels of Horizon 2020 engagement is essential for designing more effective policy interventions and support mechanisms.

To investigate these dynamics, this study draws on a comprehensive dataset of Italian SMEs that participated in Horizon 2020. Through descriptive and econometric analyses, the study segments firms based on their participation levels and examines key funding efficiency indicators, such as average contribution per project. The goal is to provide nuanced insights into how firm age, participation complexity, and other structural factors influence funding success. The findings aim to inform future policy interventions by identifying the specific challenges faced by SMEs and offering targeted recommendations to enhance their ability to leverage EU funding effectively.

2. RELATED WORK

In the existing literature, a significant body of research has explored the impact of funds dedicated to innovation. Numerous research papers have highlighted the positive effects of subsidies on firms' R&D activities, including stimulating technological advancements and promoting growth in innovation output. For example, Almus and Czarnitzki (2003), González and Pazó (2008), and Hussinger (2008), Busom and Fernández-Ribas (2008), Aerts and Schmidt (2008), Gussoni and Mangani's (2010), and Foreman-Peck (2013) emphasize that public subsidies significantly support innovation-related activities within firms.

On the other hand, some research presents less favorable outcomes, suggesting that while subsidies may increase R&D expenditure, they do not always lead to corresponding success in innovation output (Catozzella & Vivarelli, 2011; Cerulli & Potì, 2008; Hashi & Stojčić, 2013). Furthermore, several studies report mixed or neutral findings on the relationship between public subsidies and private innovation expenditures. For instance, Callejon and García-Quevedo (2005) highlight sector-specific differences, while Cerulli and Potì (2012) identify a lack of effect in certain firms, particularly noting a more pronounced "crowding-out" effect among smaller firms. Bronzini and Piselli (2016) found that subsidies significantly boosted patent filings, particularly for smaller firms, although larger firms did not experience the same level of benefit. In the context of European Union (EU) funding, studies focusing on Horizon 2020 and its predecessors have shown that EU subsidies can substantially stimulate innovation activities across various industries. Czarnitzki and Lopes-Bento (2014); Mulligan et al. (2019) have highlighted the importance of combining regional, national, and EU subsidies, showing that firms receiving mixed funding are more likely to engage in radical product and service innovation. In contrast, single-source funding, whether from the EU or national sources, may be less effective in fostering breakthrough innovations (Garcia & Mohnen, 2010).

The literature on SMEs' participation in EU research and innovation programs is more limited. Čučković and Vučković (2021), revealed that SMEs in new EU member states benefited significantly from EU research and innovation (R&I) funding. The study found that these firms not only performed better in innovation but also had a higher probability of attracting additional private investment. Similarly, Piątkowski (2020) highlighted the positive effects of EU subsidies on Polish firms, noting improvements in product innovation, business performance, and the perception that these funds were crucial for the companies' development.

One of the most notable components of Horizon 2020 is the SME Instrument, which provided a structured tool to support small firms in their efforts to innovate. Modeled on the U.S. Small Business Innovation Research Program, the SME Instrument consists of a three-phase structure focused on supporting early-stage development and commercialization. Despite high levels of interest from SMEs, the highly competitive nature of this instrument means that many applicants do not secure funding (Di Minin et al., 2016). Vidmar and Vukasinović (2019) highlight that successful participants often have prior experience with EU projects, which gives them an

advantage when applying for these funding. Similarly, Enger and Castellacci (2016) demonstrate that prior participation in EU Framework Programs not only increases the propensity to apply for Horizon 2020 but also significantly strengthens the probability of success. Research by Wanzenböck et al. (2020) emphasizes the importance of networking, arguing that strong partnerships with experienced consortia enhance the likelihood of securing funds.

SMEs that do manage to secure Horizon 2020 funding tend to exhibit significant growth in turnover, employment, and innovation intensity, as noted by Mulier and Samarin (2021). Moreover, these firms report higher rates of patent filings, demonstrating that Horizon 2020 plays a crucial role in fostering tangible innovation outcomes (Basosi et al., 2021).

In analyzing the participation of diverse types of organizations in European Framework Programmes, several factors that hinder participation have been considered. Results from surveys of Norwegian FP participants and non-participants, as studied by Åström et al. (2017) reveal that the main barriers to Horizon 2020 participation include lack of time, limited administrative support, complex rules for participation, and difficulties in identifying relevant calls for proposals. Additionally, wage disparities across countries, particularly in low-income member states, limit participation by making it harder to attract researchers and to cover project costs within the available funding (Puukka, 2018).

Finally, participation in Horizon 2020 is not only about overcoming barriers but also about capitalizing on critical success factors. Research into European Union-funded research, development, and innovation (RDI) projects under Horizon 2020 suggests that successful project management relies on several important factors. These include the implementation of good practices in managing complex projects, the skills and qualities of coordinators, and effective collaboration in multicultural project environments, which must be prioritized for effective project execution (Tenhunen-Lunkka & Honkanen, 2024).

Beyond studies that focus on analyzing the impact of European programs, the literature offers fewer studies aimed at examining the participants themselves, particularly from the perspective of more or less active actors in these programs. While this aspect has been considered to some extent, most studies focus on country-level participation rather than the participation of different organizations (Folea, 2017; Bralić, 2017; Ferrer-Serrano et al., 2021; Gallo et al., 2021; Sekerci & Alp, 2023). Among various organizations, research institutions have received more attention in studies related to European programs dedicated to research and innovation (Enger & Castellacci, 2016; Enger, 2018, 2020; Bērziņa, 2020), with significantly fewer studies focusing on firms. Furthermore, among firms, large enterprises are studied more frequently (Børing et al., 2020) than small and medium-sized enterprises (Abreu et al., 2023).

There is comparatively less literature examining the characteristics of participants that determine the success and intensity of participation in innovation programs. Studies that do focus on organizational-level participation often emphasize the advantages held by research institutions and large enterprises, with significantly fewer studies addressing SMEs' participation. Even fewer studies investigate the specific properties of SMEs, such as age, size, sector, and prior experience, which may influence their success in obtaining and utilizing funding. This study aims to contribute to the literature by addressing these gaps, focusing specifically on Italian SMEs' participation in Horizon 2020. By analyzing both single and multi-project participants, we provide insights into how firm-level characteristics shape funding success and engagement intensity within the program.

3. ITALY IN HORIZON 2020

Italy ranked third among European powers and holds the 10th position in the global ranking of world economies for the year 2023. Despite its prominent economic standing, according to the *European Union Scoreboard 2024*, Italy is classified as a moderate innovator, alongside countries such as Slovenia, Spain, Czechia, Malta, Lithuania, Portugal, Greece, and Hungary; with an R&D intensity of 1.48%, positioning it 15th out of 28 EU countries, falling below the EU average of

2.3%. In addition, Italy ranks 22nd in terms of researchers per million population compared to other EU countries. The relative strengths of the Italian innovation system include intellectual assets, attractive research systems, and the presence of innovators. However, weaknesses are evident in areas such as linkages, finance and support, and firm investments. Distinct characteristics of the Italian economy include a higher share of micro enterprises in turnover, a smaller share of large enterprises, fewer foreign-controlled enterprises, a lower number of top R&D spending companies, and a smaller share of enterprise births. Moreover, Italy has experienced lower and even negative GDP growth, highlighting further challenges within the country's innovation ecosystem (Puukka, 2018).

This interesting observation aligns with the findings of Savrul and Incekara (2015), who suggested that the innovation rank and R&D intensity can indicate a discrepancy between innovation performance. Their study highlights that some countries may have a much lower innovation performance score than expected, given their R&D intensity. In contrast, some other countries may achieve better innovation performance with comparatively lower investment. This reflects the broader challenge faced by Italy, where despite moderate levels of R&D intensity, the country struggles to translate this into strong innovation outcomes. This misalignment between investment and performance suggests that structural factors, including the efficiency of innovation processes, linkages between research and industry, and the absorptive capacity of firms, play a crucial role in determining innovation performance.

Italy's performance in Horizon 2020 reveals a mixture of strengths and weaknesses. Although Italy invests significantly less in R&D compared to its key European partners, the country boasts a highly productive public science system. However, R&D investments from the private sector remain low, largely due to structural issues such as limited investments in the science base, compounded by the effects of the economic recession and cuts in higher education funding. Persistent regional inequalities and a low absorptive capacity within the SME-based economy, as well as challenges in the coordination and management of the RDI system, further hinder progress. According to the Horizon Dashboard accessed in September 2024, Italy has seen a decline in its standing in terms of funds received, moving from fourth place in FP7 to fifth in Horizon 2020, with €5.71 billion secured, trailing behind Germany, the United Kingdom, France, and Spain. With Italy representing around 13% of the European Union's population, the normalized Horizon 2020 funding per inhabitant was only €97, compared to the EU-27 average of €146, placing Italy behind 15 other countries¹.

Despite Italy nearly doubling its participation in proposals under Horizon 2020 compared to FP7, the success rate – measured as the ratio of signed grants to proposals – declined from 18% in FP7 to 13% in Horizon 2020, highlighting the increasing difficulty in securing funding. In terms of institutional performance, the top contributors were the National Research Council (CNR) with 779 participants and €314.09 million, Politecnico di Milano with 444 participants and €188.07 million, and Alma Mater Studiorum Università di Bologna with 361 participants and €155.84 million. Among SMEs, notable performers were Deep Blue SRL (€14.64 million), Stam SRL (€13.78 million), and Solydera SPA (€12.42 million). The participation of SMEs under Horizon 2020 also saw a significant rise, partly due to the introduction of the SME Instrument² and other initiatives aimed at encouraging their involvement (Åström et al., 2017). While SMEs accounted for 32% of total proposals under FP7, this increased to 42% in Horizon 2020. However, in terms of signed grants, SMEs only saw a slight increase in their share, from 33% under FP7 to 36% in Horizon 2020. Like overall participation trends, SMEs also experienced a substantial drop in their success rate, falling from 19% in FP7 to 11% in Horizon 2020, further indicating the heightened competition for funding in Horizon 2020.

¹ The data are calculated using information from Eurostat on the EU population as of January 1, 2024, and the total Net EU Contribution from Horizon 2020 in the Horizon Dashboard, accessed in September 2024.

² SME instrument supports close-to-market activities with the aim of contributing to breakthrough innovation and primarily targets highly innovative SMEs with a clear commercial ambition and a potential for high growth and internationalization. There are two phases, feasibility assessments (phase 1) with a €50k lump-sum funding, and innovation projects (phase 2) with funding in the range €500k–€2.5m, normally covering up to 70 percent of eligible costs.

Italy has introduced a range of policies to enhance participation in Horizon 2020 and support its broader research, development, and innovation (RDI) activities. Key initiatives include aligning the National Research Programme (PNR) 2015-2020 with Horizon 2020 and Cohesion policies, prioritizing applied and translational research, and allocating significant resources to human capital development. Additionally, the National Smart Specialization Strategy was coordinated with Horizon 2020 and the PNR to ensure complementarity. Italy has also enhanced coordination between national ministries, National Contact Points, and EU representatives, while offering incentives for European Research Council (ERC) participation, such as funding for ERC winners to build research teams in Italy. Other measures include matched funding for Joint Programming Initiatives, an increase in performance-based funding for universities, and the introduction of the 'Industria 4.0' initiative and the Startup Act, which provide tax incentives and support for R&D activities across various phases, fostering an innovation-friendly ecosystem for start-ups.

4. RESEARCH HYPOTHESIS

Existing literature has extensively examined the role of firm age in shaping innovation capacity and performance, but from different angles. For example, Autio et al. (2000) and Sørensen & Stuart (2000) focus on how age influences organizational routines, networks, and the ability to exploit market opportunities. They argue that older firms benefit from accumulated experience and established networks, which enhance their ability to secure funding and navigate complex project environments. Conversely, younger firms tend to display greater flexibility and innovative potential but often lack the organizational maturity and financial infrastructure necessary to fully capitalize on such opportunities. Other studies, such as those by Veugelers and Cincera (2015) and Čučković and Vučković (2021), have analyzed firm age in relation to access to public R&D funding, highlighting structural barriers that younger firms face, such as limited access to early-stage financing and smaller presence in high-R&D-intensity sectors. Similarly, Coad et al. (2018) explore the non-linear relationship between firm age and performance, finding that younger firms initially face a "liability of newness," which limits their ability to translate innovation into financial success. However, as firms mature, they tend to benefit from organizational learning and experience, though this advantage can erode over time due to increased rigidity ("liability of old age"). Furthermore, Mabenge et al. (2022) investigate the differential impact of marketing innovation on financial performance across firm age groups, showing that younger firms benefit more from innovation than older firms due to their agility and proactive business strategies. Other research has focused on barriers to financing for young and small firms, with Veugelers (2008) highlighting that young, innovative companies (YICs) face greater financial constraints when attempting to secure funding for high-risk, innovation-focused projects. Young Innovative Companies (YICs) represent a small but important group within the SME landscape. Despite their small number, they account for a disproportionately high share of radical innovations, suggesting that younger firms may have a strategic advantage when applying for Horizon 2020 funds due to their innovative capacity. However, their greater vulnerability to financial and operational pressures makes it more challenging for them to sustain long-term engagement, especially when managing the complexity of multiple projects.

While these studies have examined the link between firm age and innovation capacity or financial performance at a broad level, there is limited research exploring how firm age affects funding efficiency – specifically the ability to convert R&D funding into tangible project-level outcomes. This study aims to fill this gap by focusing on the relationship between firm age and contribution per project (i.e., the average amount of Horizon 2020 funding received per project). Contribution per project reflects not only the firm's capacity to secure funding but also its ability to manage and utilize financial resources effectively within the framework of complex R&D projects. The focus on contribution per project represents a shift from previous research, which has primarily studied age-performance relationships in terms of broader financial outcomes, such

as profitability or growth rates. By examining how age influences project-level funding efficiency, this study seeks to uncover whether younger firms' agility or older firms' experience translates into more effective use of public R&D funding. This deeper, more granular approach allows for a nuanced understanding of how firm-level characteristics shape funding success and absorptive capacity within Horizon 2020. Building on this framework, the following hypotheses are proposed:

H1: Among SMEs participating in a single Horizon 2020 project, younger firms are expected to achieve lower funding efficiency (measured as the average contribution per project) compared to older firms, due to their limited organizational maturity and financial capacity.

H2: Among SMEs participating in a single Horizon 2020 project, younger firms are expected to achieve higher funding efficiency compared to older firms, as their flexibility and innovative potential may allow them to maximize the impact of initial funding opportunities.

H3: Among SMEs participating in multiple Horizon 2020 projects, older firms are expected to achieve higher funding efficiency due to their accumulated experience and ability to manage complex project demands more effectively.

H4: Among SMEs participating in multiple Horizon 2020 projects, older firms are expected to achieve lower funding efficiency due to organizational rigidity and diminishing returns from repeated project engagement.

These hypotheses provide a framework for analyzing the relationship between firm age and funding efficiency across different levels of Horizon 2020 participation. By distinguishing between single and multi-project participants, this study aims to generate deeper insights into how firm-level characteristics shape funding success and absorptive capacity within the Horizon 2020 framework.

5. DATA AND VARIABLES

The primary source for our analysis was the open dataset CORDIS³. This dataset, accessed in December 2022, served as a valuable resource for information related to projects under Horizon 2020 in which Italian SMEs participated. It provided data on 1593 Italian SMEs, which represents the unique participation of these SMEs in Horizon 2020, considering that each of them engaged in at least one project. Consequently, the total unique participation of Italian SMEs in Horizon 2020 projects as of December 2022 amounted to 2021. Thus, our sample accounts for approximately 79% of our population of interest, making it sufficiently representative. We excluded 428 SMEs from our study randomly due to the unavailability of their data at the firm level. From CORDIS, we collected the following data: Tax Identification Number (TIN) as an identifier for each SME, project ID for aggregating total amount of funds (Net EU Contribution) and the total number of projects in which an SME participated, the geographic location, Horizon 2020 pillars, prior participation in FP7. We performed web scraping from <https://www.ufficiocamerale.it>, gathering valuable firm-level data to complement the existing dataset, including years of operation⁴, the number of employees⁵, legal form⁶, and core business activity⁷. In all data sources used, firms were identified by their TIN number, which was used to link the datasets. For each SME, we calculated the average funds received from Horizon 2020,

³ CORDIS is the Community Research and Development Information Service of the European Union. It is the primary source of information for the European Commission on the results of projects funded by the EU's research programs.

⁴ They are grouped into four categories by the author, ranging from fewer years (1-5 years) to more than 25 years, without reference to any specific categorization.

⁵ Referring to the SME categories defined by EU Recommendation 2003/36. Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (notified under document number C(2003) 1422) (Text with EEA relevance) (2003/361/EC).

⁶ The classification is based on the distribution of data across categories, emphasizing the categories with the highest number of participants, while grouping all other forms with lower participation into the "Other" category.

⁷ Based on the NACE code level (SIC2007), this variable is divided into four categories, following the same rationale as the classification used for the legal form.

referred to as Contribution per Project; by dividing the total funds received – calculated as the aggregated Net EU Contribution across all projects in which the SME participated – by the total number of projects it was involved in. The distribution of Italian SMEs participating in Horizon 2020, shown in Table 1, is analyzed for the entire sample (1593 SMEs), SMEs that participated in 1 project (1096 SMEs), and SMEs engaged in 2 or more projects (497 SMEs).

Table 1. SME Distribution in Horizon 2020 across Subsamples

	All SMEs		1 Project		< 1 Project	
	Nr.	%	Nr.	%	Nr.	%
Age						
1-5 years	89	6%	67	6%	22	4%
6-15 years	704	44%	488	45%	216	43%
16- 25 years	392	25%	241	22%	151	30%
Over 25 years	408	26%	300	27%	108	22%
Size						
Micro SME (0-9)	740	46%	527	48%	213	43%
Small SME (10-49)	579	36%	386	35%	193	39%
Medium SME (50-250)	274	17%	183	17%	91	18%
Location						
Center	366	23%	228	21%	138	28%
Islands	35	2%	26	2%	9	2%
North East	435	27%	302	28%	133	27%
South	170	11%	110	10%	60	12%
Northwest	587	37%	430	39%	157	32%
Legal form						
JSC	254	16%	177	16%	77	15%
LLC	1271	80%	866	79%	405	81%
Other	68	4%	53	5%	15	3%
Sector						
I&C Services	326	20%	208	19%	118	24%
PS&T Activities	517	32%	296	27%	221	44%
Other	180	11%	141	13%	39	8%
Manufacturing	570	36%	451	41%	119	24%
H2020 Pillar						
Excellent Science + Other	na	na	101	9%	na	na
Industrial Leadership	na	na	439	40%	na	na
Societal Challenges	na	na	556	51%	na	na
FP7 Participation						
Yes	370	23%	251	23%	119	24%
No	1223	77%	845	77%	378	76%
Total SMEs	1593	100%	1096	100%	497	100%

Source: CORDIS dataset, accessed in December 2022.

The distribution indicates a high degree of similarity across the variables Age, Size, Location, Legal Form, and FP7 Participation, with only the Sector showing a notable difference between the subsamples. Manufacturing SMEs dominate in the 1-project subsample, representing 41% of SMEs. In contrast, SMEs in Information and Communication (I&C) Services dominate in the multi-project subsample, rising from 27% to 44%. This sectoral shift indicates that manufacturing SMEs are more likely to participate in one project, possibly reflecting resource limitations or sector-specific constraints. I&C Services SMEs are more likely to engage in multiple projects, likely due to their higher absorptive capacity, innovation orientation, and R&D focus.

6. ECONOMETRIC MODELS

To evaluate the effect of firm age on funding efficiency in Horizon 2020 projects, a set of Generalized Least Squares Models (GLS) was estimated. The dependent variable in the models is the log of the average contribution per project, which allows for the interpretation of coefficients as percentage changes relative to the reference category. The primary objective of the analysis is to assess whether younger firms are more or less efficient than older firms in securing and utilizing Horizon 2020 funding, while controlling for other firm-specific and contextual characteristics that might bias the estimated effect of firm age.

Firm age is the key explanatory variable of interest and is included in the model as a categorical variable with four levels: 1-5 years, 6-15 years, 16-25 years, and over 25 years (reference category). The coefficients for the age categories represent the estimated percentage change in funding efficiency relative to the reference category. The goal is to isolate the direct effect of firm age on funding efficiency by holding other firm-level and contextual factors constant. To control for potential confounding effects and ensure that the estimated effect of firm age is not influenced by other firm-specific characteristics, the following independent variables are included as controls: size (micro, small, and medium), location (center, islands, northeast, south, and northwest), legal form (JSC, LLC, other), sector (I&C services, PS&T activities, other, manufacturing), H2020 pillar (strategic focus of the Horizon 2020 project, included only for single-project participants), and FP7 participation (binary indicator of whether the firm previously participated in FP7, reflecting prior experience and reputation). By including these control variables, the analysis isolates the direct effect of firm age on funding efficiency. This means that the estimated coefficients for firm age reflect the net effect of age, independent of the influence of other firm-level characteristics.

Three separate GLS models were estimated to distinguish the effect of firm age across different levels of project complexity and engagement. Model 1 (baseline model) includes the full sample of SMEs participating in Horizon 2020, providing a general overview of the relationship between firm age and funding efficiency. Model 2 includes only SMEs that participated in a single project under Horizon 2020, allowing for the analysis of funding efficiency in a low-complexity setting where firms face fewer administrative and operational challenges. Model 3 includes only SMEs that participated in multiple projects over the seven-year period of the program, capturing the impact of increased administrative and operational complexity on funding efficiency. This approach allows for a detailed examination of how firm age influences funding efficiency under different project participation structures. Specifically, Model 2 isolates the effect of age when firms are involved in only one project, reflecting lower complexity and resource demands, whereas Model 3 isolates the effect of age when firms are involved in multiple projects, capturing the challenges associated with greater administrative and operational complexity. The division of the sample into these two subsamples provides a structured framework for evaluating the relationship between firm age and funding efficiency, distinguishing between firms with one-time participation and those with ongoing involvement in Horizon 2020. This approach ensures a nuanced analysis of how absorptive capacity and firm-level characteristics influence funding outcomes across different levels of program engagement. The econometric model is specified as follows:

$$\text{Log} \left(\frac{\text{Contribution}}{\text{Project}} \right) = \alpha + \beta_1 \text{Age}_i + \sum_{j=2}^k B_j \text{Controls}_{ji} + \varepsilon_i \quad (1)$$

To address potential outliers and skewed funding distributions, as illustrated by the histograms and box plots in Graph 1 and Graph 2 in the Appendix, a logarithmic transformation was applied to the dependent variable (average contribution per project). This transformation helps to normalize the data and reduce the influence of extreme values, enhancing the robustness of the analysis. Given the presence of heteroskedasticity in the dataset (i.e., non-constant variance of the residuals), a Generalized Least Squares (GLS) estimator was used instead of an Ordinary Least Squares (OLS) estimator. GLS modifies the OLS objective function to account for the varying

error variance, ensuring more efficient and unbiased estimates. This adjustment increases the reliability of the estimated coefficients by improving the model's fit to the data.

7. RESULTS

The results of the analysis provide important insights into the relationship between firm age and funding efficiency in Horizon 2020 projects, distinguishing between single and multi-project participation. This section presents the findings from the Two-Way ANOVA and the Generalized Least Squares (GLS), highlighting the patterns observed across different age groups and levels of project engagement. The analysis aims to test the four research hypotheses formulated earlier regarding the effect of firm age on funding efficiency, while controlling for firm size, location, legal form, sector, Horizon 2020 pillar, and prior FP7 participation.

7.1. Results from the Two-Way ANOVA

The Two-Way ANOVA results, presented in Table 2, provide an overview of the mean contribution per project across different categories of firm age, size, location, legal form, sector, and prior FP7 participation. The mean contribution per project for the full sample of SMEs is €254,667, with significant differences between single-project participants (€242,348) and multi-project participants (€281,834). This suggests that firms engaged in multiple projects tend to secure higher average funding per project, reflecting the potential advantages associated with accumulated experience and improved absorptive capacity. The p-values for all explanatory variables are statistically significant ($p < 0.05$), indicating that the differences observed across subsamples are meaningful and unlikely to be due to random variation.

Focusing on firm age, significant differences in mean contribution per project are observed across age groups ($F = 4.43$, $p = 0.035$). In the full sample, younger firms (1–5 years) exhibit the lowest average contribution per project, while firms aged over 25 years achieve the highest. The pattern shifts when comparing single versus multi-project participants. Among single-project participants, younger firms (1–5 years) receive an average of €222,657 per project, while older firms (over 25 years) receive €230,641. In contrast, among multi-project participants, younger firms' average contribution per project drops to €203,825, while older firms' average contribution increases to €346,333. Firms aged 1-5 years show a negative mean difference of - €18,832, indicating that younger firms face significant performance declines when transitioning from single to multi-project participation. This pattern reflects the structural disadvantages that younger firms may encounter when managing more complex project demands.

Negative mean differences are also observed for other firm-level characteristics, highlighting additional structural challenges. Regarding location, firms based in the Islands region exhibit a significant negative mean difference of - €45,779 between single and multi-project participation. This suggests that firms in the Islands region face greater difficulties in sustaining funding efficiency when increasing their project engagement, possibly due to logistical or operational constraints. In terms of legal form, firms categorized under the "Other" legal form exhibit a negative mean difference of - €32,685 between single and multi-project participation. This implies that firms with less formalized or less structured legal frameworks may struggle more with the administrative and operational challenges associated with multi-project engagement.

Table 2. Two-Way Anova

	All SMEs	1 Project	< 1 Project	Two - Way Anova			
	Mean	Mean	Mean	Mean Diff.	F_value	Df	p_value
Age					4.43008	3	0.03547
1-5 years	218002	222657	203825	-18832			
6-15 years	257622	254157	265452	11295			
16- 25 years	250818	238485	270501	32016			
Over 25 years	261265	230641	346333	115692			
Size					4.47110	2	0.03463
Micro SME (0-9)	217774	211936	232216	20280			
Small SME (10-49)	278127	271387	291607	20220			
Medium SME (50-250)	304733	268676	377244	108568			
Location					4.42877	4	0.03550
Center	242666	221073	278341	57268			
Islands	270686	282457	236678	-45779			
North East	239645	222212	279230	57018			
South	223151	205155	256145	50990			
Northwest	281455	274861	299516	24655			
Legal form					4.42758	2	0.03552
JSC	275190	264351	300105	35754			
LLC	247813	233506	278404	44898			
Other	306133	313343	280658	-32685			
Sector					4.50897	3	0.03387
I&C Services	232560	221048	252851	31803			
PS&T Activities	234472	224318	248072	23754			
Other	172550	156319	231231	74912			
Manufacturing	311561	290901	389357	98456			
H2020 Pillar					na	na	na
Excellent Science + Other	na	285008	na	na			
Industrial Leadership	na	209586	na	na			
Societal Challenges	na	260467	na	na			
FP7 Participation					4.42496	1	0.03557
Yes	257236	254164	263716	9552			
No	253890	238839	287538	48699			
Total SMEs	254667	242348	281834	39486			

Source: CORDIS dataset, accessed in December 2022.

7.2. Results from GLS Models

The three GLS models presented in table 3 provide detailed insights into how firm age influences funding efficiency (measured as contribution per project) under different levels of Horizon 2020 participation. The reference category for age in all three models is “over 25 years.”

Table 3. GLS Regression Models

	(1)		(2)		(3)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Age						
1-5 years	0.0229	0.0560 **	0.1211	0.0680 ***	-0.1812	0.0820 ***
6-15 years	0.0325	0.0320 **	0.0716	0.0400 ***	-0.0475	0.0450 **
16- 25 years	0.0660	0.0330 ***	0.0882	0.0420 ***	-0.0336	0.0450 **
Over 25 years	Ref.		Ref.		Ref.	
Size						
Micro SME (0-9)	-1.2040	0.0360 ***	-0.0974	0.0470 **	-0.0795	0.0480 **
Small SME (10-49)	-0.0265	0.0330 **	0.0094	0.0430 **	-0.0370	0.0450 *
Medium SME (50-250)	Ref.		Ref.		Ref.	
Location						
Center	-0.0151	0.0300	-0.0379	0.0390	-0.0121	0.0400
Islands	0.0449	0.0780	0.0594	0.0940	-0.0068	0.1160
North East	-0.0572	0.0280 **	-0.0780	0.0350 ***	-0.0558	0.0400 **
South	-0.0496	0.0390 *	-0.0953	0.0500 ***	-0.0492	0.0510
Northwest	Ref.		Ref.		Ref.	
Legal form						
JSC	-0.0464	0.0610	-0.0834	0.0740	-0.0760	0.0950
LLC	-0.1046	0.0560 **	-0.1661	0.0670 **	0.0031	0.0890
Other	Ref.		Ref.		Ref.	
Sector						
I&C Services	0.0361	0.0330 *	0.0441	0.0410 *	-0.1376	0.0470 ***
PS&T Activities	0.0521	0.0300 **	0.0215	0.0390 *	-0.1310	0.0440 ***
Other	-0.1203	0.0390 ***	-0.1010	0.0460 ***	-0.2372	0.0630 ***
Manufacturing	Ref.		Ref.		Ref.	
H2020 Pillar						
Excellent Science + Other			0.0763	0.0510 *		
Industrial Leadership			-0.0943	0.0300 ***		
Societal Challenges	Ref.		Ref.		Ref.	
FP7 PARTICIPATION						
Intercept	-0.0021	0.0270	0.0103	0.0340	-0.0276	0.0350
	5.3073	0.0630 ***	5.2903	0.0770 ***	5.5582	0.0990 ***
Adj. R Squared		0.0220		0.0330		0.0470
F statistics		3.4290		3.1650		2.6330
Prob. F Statistics		0.0000		0.0000		0.0008
AIC		1952		1446		339
BIC		2038		1436		406
Nr. SMEs		1593		1096		497

***p < 0.01, **p < 0.05, *p < 0.01

Model 1 with the entire sample of SMEs participating in Horizon 2020, providing a general overview of how firm age influences funding efficiency. All coefficients for age are positive and statistically significant. This means that, on average, younger firms are more efficient in securing and utilizing funding compared to older firms. The positive effect increases with firm age up to 16-25 years, suggesting that moderately experienced firms benefit the most from Horizon 2020 funding. The result contradicts the traditional view that older firms have an advantage due to accumulated experience – younger and mid-aged firms appear to perform better in securing and using funding.

Model 2 includes only SMEs that participated in a single Horizon 2020 project. This model isolates the impact of firm age on funding efficiency when the complexity of multi-project management is not a factor. The coefficients for age are higher in Model 2 compared to Model 1 – younger firms (especially those aged 1–5 years) achieve the highest funding efficiency when participating in a single project, suggesting that younger firms benefit from the focus and lower

complexity of single-project engagement. This supports the idea that younger firms have a strategic advantage when they are not burdened by the complexity of managing multiple projects. The increase in the size of the coefficients compared to Model 1 confirms that younger firms capitalize more effectively on single-project participation due to their innovative flexibility and agility.

Model 3 includes only SMEs that participated in more than one Horizon 2020 project, representing a setting where firms face greater complexity and administrative demands. All coefficients for age categories are now negative and statistically significant. The negative coefficients signal that younger firms perform worse than older firms when participating in multiple projects. The strongest negative effect is for the youngest firms (1–5 years), suggesting that younger firms face the greatest challenges in managing the complexity and operational burden of multiple projects. This reflects the “liability of newness” – while younger firms are flexible and innovative, they struggle with administrative and managerial demands when participating in multiple projects.

While the focus of this analysis is on age, the models reveal additional insights regarding other control variables, particularly sectoral dynamics, firm size, location, legal form, Horizon 2020 pillars, and FP7 participation. Sectoral patterns reflect a similar shift to what is observed with age. For SMEs participating in 1 project, sectors like Information & Communication (I&C) Services and Professional, Scientific & Technical (PS&T) Activities exhibit significant positive effects on contribution per project. However, in multi-project participation, the positive effects for both sectors decline significantly and turn negative. SMEs in knowledge-intensive sectors like I&C Services and PS&T Activities perform strongly when engaged in single projects. This reversal suggests that while firms in knowledge-intensive sectors are well-positioned to capitalize on single project participation, they encounter significant challenges in sustaining funding efficiency when managing multiple projects. The increased complexity and administrative burden associated with multiple projects may outweigh the advantages of specialized expertise and innovative capacity in these sectors.

Larger SMEs, particularly Medium SMEs, benefit from greater organizational capacity, better access to networks, and established processes that enable them to absorb and manage larger funding amounts efficiently. Micro SMEs, on the other hand, face substantial resource constraints that limit their absorptive capacity. SMEs located in the Northwest appear to benefit from better infrastructure, innovation ecosystems, and institutional support, which are critical for absorbing Horizon 2020 funding. Regional disparities highlight the need for targeted policies to improve funding outcomes in less competitive areas. While LLCs dominate the SME landscape, their contribution per project is lower, particularly in the single-project group. This may reflect structural inefficiencies or reduced flexibility compared to other legal forms when managing Horizon 2020 funds.

The inclusion of Horizon 2020 pillars in model 2 provides critical insights. The positive association with “Excellent Science” highlights the value of fundamental research and knowledge generation projects. The negative effect for “Industrial Leadership” may reflect the higher competition or resource-intensive nature of such projects, reducing the per-project contribution efficiency. Across all models, FP7 participation does not appear to significantly influence the contribution per project, as evidenced by small and statistically insignificant coefficients (e.g., Model 1: -0.0021). Prior participation in FP7 does not automatically translate into better funding absorption under Horizon 2020.

8. ROBUST REGRESSION FOR VALIDATION

To validate the findings from the Generalized Least Squared (GLS) and ensure the robustness of the results, a robust regression approach was applied. Robust regression is particularly useful when the data may be influenced by outliers or heteroskedasticity, which can distort the estimated coefficients and lead to biased or unstable results in traditional regression models. Unlike GLS, which minimizes the sum of squared residuals and is therefore sensitive to extreme values, robust regression assigns lower weights to outliers, reducing their influence and improving the overall stability and reliability of the model estimates. This approach enhances the robustness of the findings, allowing for a more precise evaluation of the relationship between firm age and funding efficiency. The method minimizes a robust loss function $\rho(u)$, where:

$$Q(\beta) = \sum_{i=1}^n \rho \left(\frac{y_i - x_i^T \beta}{\hat{\sigma}} \right)$$

The robust regression model was estimated using the Huber loss function, which was selected over other available loss functions (such as Tukey's biweight or least absolute deviation) due to its balanced handling of both small and large residuals. The Huber loss function combines the properties of squared loss (which is efficient for small residuals) and absolute loss (which is resistant to large residuals), making it well-suited for datasets with moderate contamination from outliers. The Huber loss function is defined as:

$$\rho(u) = \begin{cases} u^2/2, & \text{if } |u| \leq c \\ c * |u| - c^2/2, & \text{if } |u| > c \end{cases}$$

Where:

- $u = \frac{y_i - x_i^T \beta}{\hat{\sigma}}$ is the scaled residual (normalized by the estimated scale parameter $\hat{\sigma}$).
- C is a tuning constant that determines the threshold between squared and absolute loss. The default value in statsmodels is $c = 1.345$, which balances efficiency and robustness.

For small residuals, the Huber loss behaves like squared loss, preserving the efficiency of GLS under normal error distribution. For large residuals, it switches to absolute loss, down-weighting the influence of extreme values and increasing the model's robustness to outliers. This flexibility makes the Huber loss particularly suitable for financial data, where the presence of outliers is common due to variation in project funding outcomes.

The choice of Huber loss over other loss functions is motivated by the need to retain statistical efficiency while minimizing the influence of extreme observations. Tukey's biweight function, for example, aggressively down-weights large residuals, which can lead to loss of information. Least absolute deviation (LAD), on the other hand, treats all residuals symmetrically but can produce less efficient estimates when the data is approximately normally distributed. The Huber loss strikes an optimal balance between these two extremes, making it ideal for models where most observations follow a consistent pattern, but a small proportion of influential outliers may be present.

The robust regression model follows the same specification as the GLS models to allow for direct comparison. The results are presented in Table 4.

Table 4. Robust Regression Models

	(1)		(2)		(3)	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Age						
1-5 years	0.0048	0.0550 ***	0.0961	0.0660 *	-0.1730	0.0770 **
6-15 years	0.0193	0.0310 **	0.0417	0.0380 *	-0.0300	0.0420 ***
16- 25 years	0.0624	0.0320 **	0.0802	0.0400 **	-0.0253	0.0420 ***
Over 25 years		Ref.		Ref.		Ref.
Size						
Micro SME (0-9)	-0.1179	0.0360 ***	-0.0917	0.0450 **	-0.0861	0.0450 **
Small SME (10-49)	-0.0347	0.0330 *	-0.0001	0.0410	-0.0561	0.0420 *
Medium SME (50-250)		Ref.		Ref.		Ref.
Location						
Center	-0.0074	0.0300	-0.0207	0.0370	-0.0101	0.0380
Islands	0.0420	0.0760	0.0608	0.0900	-0.0272	0.1090
North East	-0.0585	0.0280 **	-0.0745	0.0340 **	-0.0638	0.0380 **
South	-0.0426	0.0380 *	-0.0908	0.0480 **	-0.0384	0.0480
Northwest		Ref.		Ref.		Ref.
Legal form						
JSC	-0.0480	0.0600	-0.0867	0.0710 *	-0.0189	0.0900
LLC	-0.1010	0.0550 **	-0.1663	0.0640 ***	-0.0140	0.0840
Other		Ref.		Ref.		Ref.
Sector						
I&C Services	0.0586	0.0320 **	0.0847	0.0390 **	-0.1580	0.0440 ***
PS&T Activities	0.0724	0.0300 **	0.0577	0.0370 *	-0.1583	0.0410 ***
Other	-0.1074	0.0380 ***	-0.0635	0.0440 *	-0.2583	0.0600 ***
Manufacturing		Ref.		Ref.		Ref.
H2020 Pillar						
Excellent Science + Other			0.1401	0.0490 ***		
Industrial Leadership			-0.0886	0.0290 ***		
Societal Challenges		Ref.		Ref.		Ref.
FP7 Participation	-0.0004	0.0260	0.0153	0.0320	-0.0196	0.0330
Intercept	5.2933	0.0620 ***	5.2552	0.0740 ***	5.6173	0.0930 ***
Pseudo R Squared		0.031		0.042		0.068
Nr. SMEs		1593		1096		497

***p < 0.01, **p < 0.05, *p < 0.01

The robust regression results confirm the overall patterns observed in the GLS models, reinforcing the validity of the core findings. However, the down-weighting of outliers leads to minor adjustments in the size of the coefficients, reflecting increased model stability and reduced sensitivity to extreme observations. The smaller magnitude of the coefficients in the robust regression suggests that outliers were inflating the estimates in the GLS models. The down-weighting of extreme values improves the stability of the estimates without altering the overall pattern of results.

The robust regression results confirm the validity and reliability of the GLS findings, reinforcing the conclusion that younger firms benefit from higher funding efficiency in single-project settings but face structural limitations in multi-project settings. The consistent patterns across models provide strong evidence that the relationship between firm age and funding efficiency is moderated by project complexity.

The fact that the results remain consistent across both models suggests that the observed patterns are not driven by data anomalies but reflect genuine structural differences in the ability of younger and older firms to manage complex project demands. This consistency enhances the generalizability of the findings and supports the development of targeted policy interventions to improve funding efficiency among younger and smaller firms.

9. CONCLUSIONS

There is still a pressing need for further research to encourage more effective participation of SMEs in research and innovation programs, aiming to maximize the impact of the funding they receive. While initiatives like Horizon 2020 have successfully met their quantitative funding targets for SMEs, achieving more ambitious goals, such as qualitative targets, remains a challenge. The inability to ensure high-quality SME participation persists as the Achilles' heel of the current system (Simonelli, 2016).

This study analyzed the participation of Italian SMEs in Horizon 2020, focusing on the role of firm age in shaping funding efficiency and absorptive capacity. By estimating a series of Generalized Least Squares Models (GLS) and validating the findings through robust regression, the study examined the differential effects of firm age on funding efficiency between single and multi-project participants, while controlling for other firm-specific and contextual factors. Using a comprehensive dataset of SMEs that successfully secured EU funding, we introduce a key metric – average funding per project. While similar studies, such as those by Børing et al. (2020), Heimonen (2012), and Hussinger (2008), primarily measured firm success based on total funding received, our approach provides a more detailed perspective on SME engagement within large-scale innovation programs.

The analysis tested four key hypotheses regarding the effect of firm age on funding efficiency. The findings confirm that younger firms face structural disadvantages in securing and managing Horizon 2020 funding. Specifically, **H2** is supported, as younger firms participating in a single project achieve higher funding efficiency compared to older firms, reflecting their greater flexibility and innovative potential in less complex project environments. Similarly, **H3** is supported, as older firms demonstrate higher funding efficiency in multi-project settings due to accumulated experience and greater administrative capacity. These results align with the idea that older firms benefit from established routines and stronger strategic capacity when managing complex project structures. As Veugelers et al. (2015) emphasize, a comprehensive innovation policy is necessary but not sufficient - policy interventions must specifically address the barriers that young, high-R&D-intensity firms face, including limited access to venture capital, difficulty in securing external financing, and the fragmented nature of the European risk investment market. The lower contribution per project for startups engaging in multiple projects underscores the importance of early-stage grant programs that bridge the gap during critical startup phases.

The study's findings carry important policy implications. Tailored support for younger firms—such as improved access to financial instruments and administrative support—could help them manage the complexity of multi-project participation. Encouraging knowledge transfer between younger and older firms could enhance the absorptive capacity of younger firms, improving their ability to scale project engagement. Strengthening regional support systems, particularly in underperforming regions like the Islands, could address geographic disparities in funding efficiency (Veugelers et al., 2015). Furthermore, improving alignment between public and private R&D investments could enhance the long-term impact of EU funding programs (Veugelers, 2008).

While the study provides valuable insights, certain limitations should be acknowledged. The analysis focuses solely on SMEs that successfully secured Horizon 2020 funding, excluding non-participants and unsuccessful applicants. This introduces a potential selection bias, limiting the generalizability of our findings (Børing et al., 2020; Enger & Castellacci, 2016). Future research should expand the analysis to include unsuccessful applicants, allowing for a more comprehensive assessment of the barriers that prevent SMEs from securing EU funding.

Another important avenue for future investigation is the long-term impact of Horizon 2020 participation. A key question is whether SMEs that participated in only one Horizon 2020 project have transitioned into more active engagement under Horizon Europe. Tracking the innovation trajectories and financial growth of these firms can provide critical insights into the sustainability of EU-funded SME innovation. Additionally, further research should explore the role of firm networks, prior EU project experience, and access to complementary funding sources in shaping SME participation and success rates in large-scale R&D programs.

Overall, the study highlights the dual nature of firm age in influencing funding efficiency under Horizon 2020. Younger firms benefit from innovative potential and flexibility but face barriers in sustaining performance under complex project demands. Older firms, with their accumulated experience and strategic capacity, are better positioned to manage complexity and maximize funding outcomes. These findings offer a strong foundation for designing targeted policy interventions to enhance SME participation and funding efficiency in future European research programs.

10. DATA AVAILABILITY

Data can be provided upon request.

11. FUNDING

This research received no external funding.

12. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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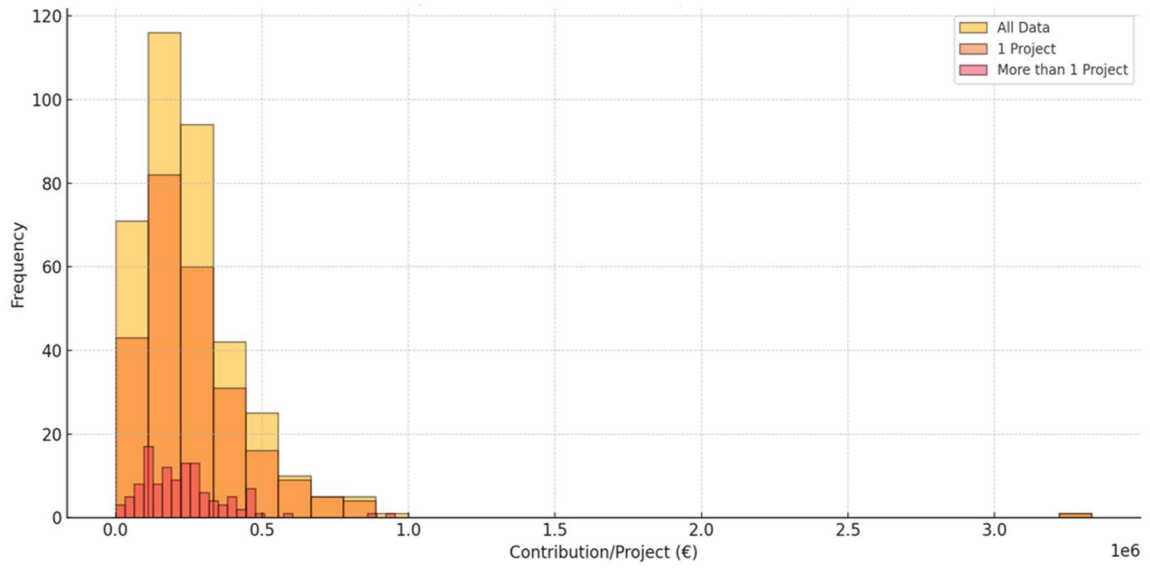
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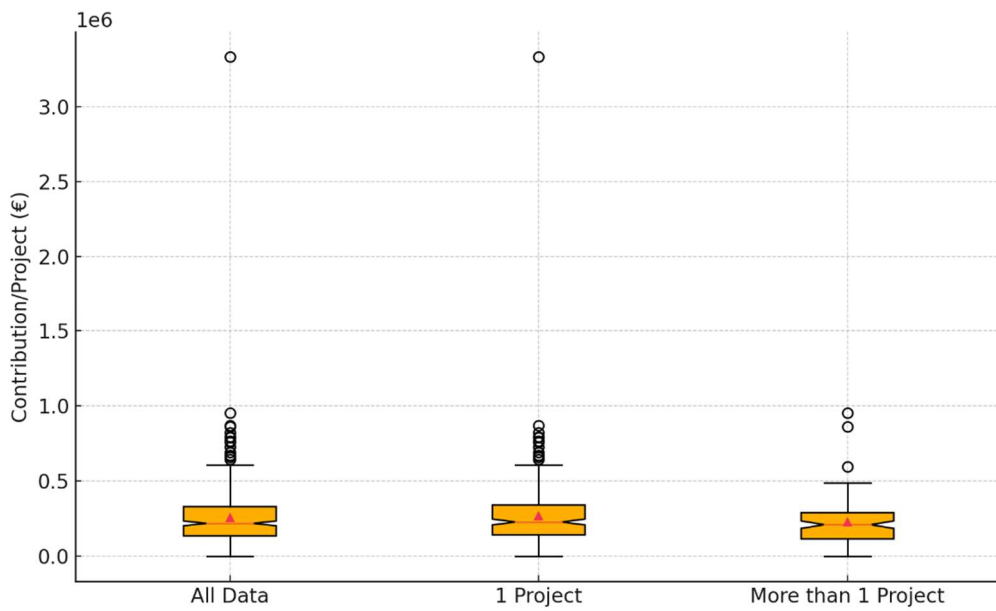
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14. APPENDIX

Graph 1. Histogram of Contribution/project



Graph 2. Boxplot of Contribution/project



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N. 1/2025 [Invecchiamento e welfare responsabile: la “condizione anziana” nelle periferie di Roma Capitale](#). Cristiana Di Pietro

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This paper presents an analysis of SME participation in the European Framework Programme for Research and Innovation (Horizon 2020), focusing on the role of firm age in shaping funding engagement and success. Our dataset comprises a broad sample of Italian SMEs, allowing us to distinguish between firms participating in a single project and those engaging in multiple projects. We find it important to distinguish two patterns of participation: single engagement, where firms participate only once throughout the entire seven-year duration of Horizon 2020, and sustained involvement, where firms secure funding for multiple projects over time. Our econometric results indicate that older SMEs, benefiting from accumulated experience and established networks, tend to perform better in multi-project participation, achieving higher funding efficiency compared to younger SMEs. In contrast, younger SMEs, while more agile and innovative, often face challenges in sustaining long-term engagement due to resource constraints and limited administrative capacity. These findings underscore the importance of firm age as a key determinant of absorptive capacity and funding success in EU research programs, with implications for policies aimed at improving SME access to international R&D funding.