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Techno-Globalism and the EU Framework Programmes: evidence from multinational parent companies and subsidiaries

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Abstract: This study examines the participation of European multinational corporations (MNCs) in EU Framework Programs (FPs) using project-level data retrieved from the EU Funding & Tenders Portal, Horizon Dashboard, and CORDIS. The research analyzes the collaboration networks formed by parent companies and their subsidiaries through participation indicators and network analysis, exploring patterns of engagement, centrality, and the role of subsidiaries in local and global knowledge exchange. Results show that MNCs widely use FPs to access strategic knowledge and technology rather than funding, with parent companies concentrated in central Europe and subsidiaries enabling the geographic dispersion of R&D activities. Network analysis reveals a collaborative structure with low density but high cohesion, consistent with a "small world" phenomenon. Subsidiaries are highly connected locally, while parent companies lead in intermediating collaborations. Internal collaboration between parent and subsidiary does not significantly affect network centrality. These findings advance understanding of technological globalization, the role of MNCs in public R&D networks and provide a replicable framework for analyzing corporate collaboration dynamics.
Keywords: Network Analysis, Innovation Networks, Corporate Internationalization, Knowledge Transfer, Public Research Funding.
JEL codes: O32; O33; F23; H57; L22; L14

ES El Tecnoglobalismo y los Programas Marco de la UE: datos de empresas matrices multinacionales y de sus filiales.

Resumen: Este estudio examina la participación de las empresas multinacionales europeas (EMN) en los Programas Marco de la UE (PM) utilizando datos a nivel de proyecto obtenidos del Portal de Financiación y Licitaciones de la UE, del Portal Horizonte Europa y de CORDIS. La investigación analiza las redes de colaboración formadas por las empresas matrices y sus filiales a través de indicadores de participación y análisis de redes, explorando los patrones de participación, la centralidad y el papel de las filiales en el intercambio de conocimientos a nivel local y global. Los resultados muestran que las EMN utilizan ampliamente los PM para acceder a conocimientos y tecnologías estratégicos, más que a financiación, con las empresas matrices concentradas en Europa central y las filiales permitiendo la dispersión geográfica de las actividades de I+D. El análisis de redes revela una estructura colaborativa con baja densidad, pero alta cohesión, en consonancia con el fenómeno del «mundo pequeño». Las filiales están muy conectadas a nivel local, mientras que las empresas matrices lideran la intermediación de las colaboraciones. La colaboración interna entre la empresa matriz y la filial no afecta significativamente la centralidad de la red. Estos hallazgos permiten avanzar en la comprensión de la globalización tecnológica y el papel de las multinacionales en las redes públicas de I+D, y proporcionan un marco replicable para analizar la dinámica de la colaboración empresarial.
Palabras clave: Análisis de redes, redes de innovación, internacionalización empresarial, transferencia de conocimientos, financiación pública de la investigación.

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1. Introduction

Collaboration in research and innovation has long been recognized as a key factor in fostering technological progress and improving outcomes. A broad stream of literature shows that cooperation between private firms, universities, technology centers, and other actors contributes positively to innovation processes and their success (Cohen et al., 2024; Wirsich et al., 2016; Etzkowitz, 2003). Much of this research has focused on identifying the conditions that shape collaboration (Ćudić et al., 2022). Factors such as geography (Audretsch & Belitski, 2024), the type of organization involved (Giannopoulou et al., 2019), or the specific nature of the innovations resulting from cooperation (Un et al., 2010; Belderbos et al., 2004) have been widely examined.

The European Union (EU) has made collaborative research a cornerstone of its innovation policy. Building on the theoretical foundations of the Triple Helix (Etzkowitz, 2003) and the demonstrated benefits of international cooperation (Vrontis & Christofi, 2021), the EU has created the Framework Programmes as its main policy instrument to support research, technological development, demonstration, and innovation (Red IDI, 2025). Since the launch of the first programme in 1984, these initiatives have grown into one of the world's largest funding schemes for collaborative R&D. Over more than four decades, they have financed 132,852 grant agreements, representing a total EU contribution of €195.6 billion to international projects spanning all stages of the research and innovation process. The overarching aim has been to strengthen collaboration among Member States, promote scientific and technological convergence, and foster cohesion within the European innovation landscape (Enger, 2020).

From the perspective of the literature on technology internationalization, the EU Framework Programmes can be interpreted as a large-scale mechanism for "techno-globalism," a concept originally defined by Archibugi and Michie (1995). Among the different modes of globalization of technology, these programmes primarily enable "global technological collaboration," understood as the joint generation of knowledge or innovations by partners located in different countries. This form of techno-globalism emphasizes cross-border cooperation as a means of creating new technological capabilities.

The topics of technology internationalization and EU research networks have both been widely analyzed, but they have generally evolved as separate research streams. On the one hand, multinational corporations (MNCs) are central in the literature on internationalization of technology, often portrayed as leaders in these processes (Liang et al., 2015; Gerybadze & Reger, 1999; Belitz, 2010). MNCs are considered unique because they participate simultaneously in the three forms of technological globalization identified by Archibugi and Michie (1995): the global exploitation of technology, global technology collaboration, and global generation of technology. On the other hand, studies of EU Framework Programme networks tend to concentrate on universities, public research organizations, and large scientific centers, which together account for 57.53% of total participations across all Framework Programmes. Small and medium-sized enterprises (SMEs), with a participation share of 15.84%, have also been the focus of considerable scholarly attention.

This leaves a notable gap. Despite the clear overlap between internationalization of technology and the collaborative structures promoted by EU Framework Programmes, the role of multinational corporations within these programmes has received far less attention. Most studies treat MNCs only indirectly, for example when examining the distributional effects of subsidies or their broader innovation strategies (Szücs, 2022; Hasanov et al., 2022). Yet MNCs appear as particularly relevant actors: they are simultaneously embedded in global corporate networks and in national innovation systems, and they operate at the intersection of local and international collaboration. Their involvement in EU Framework Programmes therefore offers a unique window into how techno-globalism materializes through public R&D support.

This paper addresses that gap by focusing specifically on the participation of multinational corporations in EU Framework Programmes, with a particular emphasis on the interaction between parent companies and their subsidiaries. The literature already shows that globalization of technology and its impacts are broad and multifaceted fields of study (Vrontis & Christofi, 2021; Hsu et al., 2015), especially in relation to multinational firms (Dachs et al., 2024; Papanastassiou et al., 2020). Framework Programmes provide a rich and accessible source of data on publicly funded collaborative R&D and innovation. It is therefore striking that the global technology collaboration promoted by MNCs through these programmes remains largely unexplored.

The theoretical motivation of this study builds on Archibugi and Michie's (1995) taxonomy of technology internationalization. While global exploitation and global collaboration are forms that involve a wide variety of actors—universities, start-ups, research centers, or public administrations—global generation of technology is a mode that can only be pursued by multinational corporations. The analysis therefore seeks to determine whether EU Framework Programmes have facilitated this form of global technology generation by examining the extent to which parent companies and subsidiaries collaborate within them.

The objectives of this study are (i) to understand in depth the participation of European multinationals in the European Union Framework Programs, and (ii) to explore the position of multinationals in collaboration networks according to their technological sectors and the distribution of research-active subsidiaries. In order to meet this objective, this study poses this research question: "*do multinational corporations engage in collaboration between parent companies and subsidiaries within the EU Framework Programmes?*". In order to tackle this question, these subquestions are proposed: "are there identifiable patterns in such collaboration?, what is the structure of the networks formed by these actors in the context of the programmes?, does collaboration between parent companies and subsidiaries improve the overall position of a multinational in the innovation network?".

Answering these questions requires both descriptive and relational analysis. The first dimension examines patterns of participation and funding, identifying how MNCs as corporate groups mobilize resources across their entities. The second dimension employs network analysis to explore how these firms and their subsidiaries are positioned within the broader network of EU Framework Programme collaborations. Together, these perspectives allow us to assess whether multinationals combine different forms of globalization of technology through their involvement in public R&D collaborations.

The dataset used for this study is constructed from the Horizon Dashboard, which provides comprehensive information on all Framework Programmes from the first (1984) to the current Horizon Europe (2021–2027). From this database, the analysis considers the top 50 multinational corporations in the EU Industrial R&D Investment Scoreboard 2024, as well as their subsidiaries operating under the same commercial name. The sample consists of 50 parent companies and 411 subsidiaries, with 6,645 non-unique project participation across three Framework Programmes, generating a collaborative ecosystem with significant financial and technological scope.

Based on this dataset, two complex networks are developed and analyzed. The first focuses on parent companies and their direct participation in the EU Framework Programmes. The second, centred on parent–subsidiary collaboration, identifies whether these entities co-participate in projects and how this affects their position in the wider network. Using social network analysis, four indicators of centrality are calculated for each node, enabling a systematic assessment of collaboration behavior.

This study makes two main contributions. First, it brings MNCs explicitly into the analysis of EU Framework Programme collaborations, an area where they have been largely overlooked. Second, it integrates insights from the literature on technology internationalization and on research collaboration networks, thereby bridging two strands of research that share common concerns but rarely intersect.

The remainder of the article is structured as follows. Next section reviews the relevant academic literature on technology internationalization and EU Framework Programme collaboration networks. The following section presents the methodology and data sources, including the design of the network analysis and the indicators employed, followed by a section that reports the empirical findings of the participation and network analysis. The paper closes with a final section in which the implications of the results are discussed.

2. Research framework

The research questions formulated in the previous section require a deep understanding of the state of the art across several areas of study that, although differentiated, present important intersections. For this reason, this literature review focuses on four main dimensions: (i) the collaboration networks established within the European Union Framework Programs for research and innovation, frequently analysed in the literature through centrality studies; (ii) the internationalization of corporate research and development activities, its effects on innovative performance, and the dynamics of coordination and knowledge transfer between headquarters and subsidiaries; (iii) the effects of subsidies on the innovative activities of multinational enterprises, and (iv) institutions and the participation of MNCs in public R&D programmes. The integration of these perspectives allows the construction of a solid theoretical foundation for subsequent analysis.

2.1. International collaboration networks and public research programs

The conditions of participation in the European Union Framework Programs, together with their mission, have led much of the literature to analyse the establishment of collaboration networks among participants and the associated transfer of knowledge and technology. The structure and functioning of these collaboration networks have been widely studied, with the Framework Programs recognized as one of the main mechanisms for transnational cooperation.

Analyses of centrality within these networks reveal common patterns. Garas and Argyrakis (2008) conclude that collaboration networks display scale-free structures, where the distribution of node connections follows a power law. Almendral et al. (2009) reach similar results, showing that a small number of nodes concentrate the majority of collaborations. More recently, Morea et al. (2024) demonstrate, through a novel methodology, the usefulness of centrality analysis to identify stable communities and leading actors over time, using the Hydrogen Valley as a case study.

The position of an actor within these networks strongly influences its opportunities for collaboration. Paier and Scherngell (2011) show that central positions facilitate the selection of partners and that these collaborations are shaped by geographical factors. Balland et al. (2019) and Kosztyán et al. (2024) confirm that the core of the H2020 network is dominated by Germany, France, the United Kingdom, Italy, and Spain. Molica and Marques Santos (2024) underline the decisive contribution of H2020, together with Cohesion Policy, to research expenditures in Eastern Europe and Mediterranean regions, while also highlighting the concentration of participation in developed regions and the weaker presence of peripheral areas.

Other contributions note that information flows are driven by participant size rather than geographic location (Almendral et al., 2009). Amoroso et al. (2020), focusing on collaborations under FP7, conclude that geographic, social, economic, and human capital distances all affect the intensity of collaboration, with peripheral and less-developed regions most negatively affected. At the same time, Lalanne and Meyer (2024) show that European Union Framework Programs reduce national and cross-border barriers, promoting collaboration across the Union. Similarly, Scherngell and Barber (2010), studying FP5, conclude that technological proximity is a key determinant of collaboration, but geographical factors also remain highly relevant.

Several studies have highlighted the different roles played by participants. Ferrer-Serrano et al. (2021), analyzing projects targeting small and medium-sized enterprises under H2020, use centrality measures to highlight the prominent position of major scientific centers, both at the national and organizational level. Calignano (2021), using data from FP7, confirms that being integrated in collaboration networks correlates with greater access to funding, new knowledge acquisition, and improved academic reputation. Similarly, Breschi and Cusmano (2006) characterize early Framework Program joint research projects as forming dense and hierarchical networks, led by key participants connected to multiple partners, and showing "small-world" properties.

Determinants of collaboration also include previous or simultaneous participation in programs, the level of financial contribution obtained, and the technological and economic profile of partners (Kosztyán et al., 2024). Almendral et al. (2009) and Paier and Scherngell (2011) highlight that actors with more collaborations are more likely to generate new ones. Enger (2018), analyzing universities, points to the existence of "closed clubs" in Framework Program participation, where access to resources and capabilities, reinforced by network position, determines success. Enger and Castellacci (2020) further underline that experience, previous participation, and scientific reputation significantly increase the probability of success.

Regarding the types of actors, universities often act as central hubs in collaboration networks, while private companies typically show low centrality despite receiving significant funding (Balland et al., 2019; Ferrer-Serrano et al., 2021). Large private companies are more likely to secure participation in major H2020 projects (Børing et al., 2019). Research institutes, meanwhile, increase their participation when they have prior proposal experience or access to national funding programs (Enger & Castellacci, 2020).

In sum, the literature on international collaboration networks under the European Union Framework Programs shows that these are scale-free and small-world structures, influenced by factors such as geography, technological proximity, experience, and reputation. Universities and research centers dominate centrality, while private companies occupy secondary positions in terms of connectivity, reflecting selective and hierarchical dynamics.

2.2. Globalization of technology

The second research stream focuses on the internationalization of research and development within multinational enterprises. Cantwell (1989) established this line of inquiry, demonstrating that international research activities generate competitive advantages and position multinationals as central actors in the global transfer of knowledge. Archibugi and Michie (1995) organized forms of globalization into three categories: global exploitation of technology, global generation of technology, and global technological collaboration.

While early contributions centered on one-way knowledge flows from headquarters to subsidiaries, more recent works describe complex innovation ecosystems in which subsidiaries play an active role, combining host-country technological capacities with those of the parent company and with international knowledge flows (Papanastassiou et al., 2020).

One of the most studied topics concerns the effects of dispersing research activities across countries on firm innovation performance. Grevesen (2001) concludes that performance tends to improve in the early stages of internationalization but deteriorates later due to higher costs and coordination challenges. However, Belderbos et al. (2023) show that dispersion yields positive results when multinationals locate in technologically advanced countries and maintain diverse technological portfolios. Information exchange—both lateral and hierarchical—also enhances innovation performance (Grevesen, 2001). Leung and Sharma (2021) compare the effects of internationalization and research intensity, finding both to positively affect innovation, with internationalization further boosting exports. Conversely, Belderbos et al. (2023) identify economies of scale as a negative factor.

Subsidiaries' role has been studied in depth. Lagerström et al. (2019) propose a framework for developing subsidiaries' capabilities, stressing their importance in shaping multinational research activities. Location choices for subsidiaries depend on agglomeration economies, the presence of other foreign research operations, proximity to centers of excellence, and the regional research and innovation capacity (Siedschlag et al., 2013). The same authors show that European multinationals value the intensity of government research spending in host regions.

Zander (1999) classifies international innovation networks into four types—duplicated, dispersed, home-centered, and diversified—showing how firm and sectoral differences generate diverse network structures.

In short, this literature portrays globalization of technology as a complex phenomenon. While internationalization may enhance innovation performance, it is also shaped by costs and organizational complexity. Subsidiaries emerge as key actors that bridge local and international technological capabilities.

2.3. Multinationals and research subsidies

The third research strand considers the effects of subsidies on multinational enterprises. Although few studies directly link European Framework Programs and multinationals, some key contributions exist.

Szücs (2020), analyzing firms included in the European Union Industrial Research Investment Scoreboard, finds that subsidies do not significantly increase research expenditures in large firms. By contrast, smaller and research-intensive firms and projects respond positively, with subsidies stimulating private investment.

Expanding to the broader literature on subsidies, multinationals—both domestic and foreign—show a stronger behavioral response in high-technology industries. Cherif et al. (2023) conclude that foreign subsidiaries translate subsidies into higher research spending and patent output. These findings underline that subsidy effects differ depending on firm size, sector, and organizational structure.

2.4. Institutions and the Participation of MNCs in Public R&D Programmes

Institutional conditions play a significant role in shaping how multinational enterprises (MNCs) engage in public R&D programmes, including the EU Framework Programmes (FPs). Prior studies show that participation and success in FPs depend not only on organizational capabilities but also on the broader institutional environment in which firms and research actors operate. Enger (2018) and Enger and Castellacci (2020), for instance, demonstrate that access to resources, prior experience, and the characteristics of national research systems influence participation patterns and success rates in these programmes.

For MNCs, institutional differences affect subsidiaries in uneven ways. Subsidiaries located in regions with stronger research infrastructures or more supportive innovation policies tend to be better positioned to join collaborative projects. Evidence on the importance of regional research capacity and government research spending (Siedschlag et al., 2013) suggests that such environments facilitate access to qualified partners, lower barriers to collaboration, and enable firms to participate more actively in EU-funded networks.

The literature on European collaboration networks also shows that national and regional institutional factors shape how organizations gain access to opportunities within FPs. These mechanisms can contribute to the emergence of "closed clubs" and reinforce cumulative advantages (Enger, 2018). Such dynamics indicate that institutions indirectly influence the involvement of MNC headquarters and subsidiaries by conditioning their ability to integrate into research networks and to mobilize internal and external knowledge sources.

Overall, institutional environments help explain cross-country variation in MNC participation in the Framework Programmes. They complement our analysis of collaboration between parent companies and subsidiaries by highlighting how contextual factors shape firms' engagement in EU-funded research projects.

2.5. Hypothesis of the study and links to the research questions

The reviewed studies provide relevant insights across the four dimensions but also reveal important gaps. Collaboration by multinationals in the Framework Programmes is generally subsumed within the broader category of "private companies" in network studies, obscuring their specific behavior. Du et al. (2023) highlight the need to examine both internal headquarters–subsidiary networks and external networks involving subsidiaries. Ribeiro et al. (2018) and Almendral et al. (2009) stress that Framework Programme networks are complex, scale-free interaction systems requiring more thorough analysis.

To address these gaps, the four strands of literature discussed above provide the conceptual foundations for our research questions. The first stream, on EU Framework Programme collaboration networks, highlights the emergence of hierarchical and small-world structures, where private companies often occupy secondary positions. This evidence directly informs our first subquestion regarding whether identifiable patterns of parent–subsidiary collaboration emerge within these networks.

The second stream, focusing on the internationalization of corporate R&D, reveals the complex and heterogeneous roles played by headquarters and subsidiaries in global knowledge creation. These insights underpin our investigation of whether internal collaboration between parent companies and subsidiaries is reflected in EU-funded R&D projects.

The third stream, addressing the effects of public R&D subsidies, suggests that large R&D performers (such as MNCs) may adopt specific strategic approaches to participation. This informs our third subquestion regarding whether internal collaboration enhances the centrality of MNCs within FP collaboration networks.

Together, these perspectives justify and support our main research question: "*Do multinational corporations engage in collaboration between parent companies and subsidiaries within the EU Framework Programmes?" which is complemented by the following subquestions:* Are there identifiable patterns in such collaboration? What is the structure of the networks formed by these actors? Does collaboration between parent companies and subsidiaries improve the overall position of a multinational in the collaboration network?

Based on the literature review and its links to these research questions, the following hypothesis is proposed:

Multinationals with greater collaboration between headquarters and subsidiaries tend to occupy more central positions in the collaboration networks formed under the European Union Framework Programmes.

3. Methodology

The extensive literature on technology internationalization, together with the long trajectory of the EU Framework Programmes since 1984, makes it increasingly necessary to adopt quantitative approaches capable of capturing large-scale patterns of collaboration. While qualitative studies have provided valuable insights into specific cases or policy dynamics, the complexity and breadth of the programmes call for systematic tools that allow a more comprehensive analysis. In this sense, network analysis offers a particularly suitable methodological framework, as it enables the identification of structural properties of collaboration and the positioning of actors within an interconnected system.

3.1. Database Construction and Methodological Considerations

The methodological process applied in this study follows five main steps: (i) the collection of information from the selected sample through the EU Funding & Tenders Portal and CORDIS; (ii) the construction of a database linking parent companies with their subsidiaries; (iii) the analysis of the dataset through two complementary methodological perspectives; (iv) the extraction of results; and (v) their discussion and interpretation.

The study is structured around two complementary perspectives. First, the participation of parent companies and subsidiaries in the EU Framework Programmes is examined through a set of quantitative indicators derived from the Horizon Dashboard and adapted to the research objectives. Indicators are defined both to visualise the activity of parent companies and to assess the interaction of parent companies with their subsidiaries (see Table 1), the latter being particularly relevant for identifying the existence of global technology generation through cross-border collaboration.

Table 1. Indicators list. Own elaboration from Horizon Dashboard.

Indicators from parent MNCs	
Indicator 01	% of participation in Framework Programmes
Indicator 02	Role in collaborative projects
Indicator 03	% of EU contribution by country and Framework Programme
Indicator 04	% of EU participation by country and Framework Programme
Indicator 05	% of aid intensity in R&D investment effort
Indicator 06	% of aid intensity in R&D investment effort by parent company
Indicator 07	Net EU contribution of parent companies in the sample by country, as % of total country contribution
Indicators from parent-subsidiary relationship	
Indicator 08	% of parent companies with subsidiary participation in the same country
Indicator 09	% of parent companies with subsidiary participation in a different country
Indicator 10	% of parent companies with subsidiary participation in both same & different countries
Indicator 11	Parent–subsidiary collaboration

3.2. Definition of participation and collaboration

In this study, participation is defined as the presence of a granted project in which an organization is listed as a beneficiary. Each organization–project pairing counts as one participation; therefore, a project involving multiple partners generates multiple participations.

Collaboration is defined strictly as joint participation of two organizations in the same granted project. If the same two organizations participate together in two different projects, this results in two distinct collaborations. This definition applies uniformly to collaborations between parent companies, between parent companies and their subsidiaries, and between subsidiaries—whether these subsidiaries belong to the same multinational group or to different corporate structures.

3.3. Duplicate management and name harmonization

A harmonization process was conducted to consolidate organizations with identical names and administrative information but different PIC numbers. Only entities whose administrative attributes (address, legal entity type, country) were consistent across records were merged. No ex-post consolidation was applied for mergers, acquisitions, or closures occurring after the award of FP grants, as these events do not affect the organizational structure at the time of project execution.

3.4. Sample definition and selection criteria

The sample of parent companies consists of the top 50 multinational corporations (MNCs) listed in the EU Industrial R&D Investment Scoreboard 2024, each with more than €900 million in R&D investment in 2023. Although this group represents only 6.25% of all firms in the Scoreboard, it captures the leading global R&D investors: 89.125% of firms in the ranking invest less than €500 million. Selecting the top 50 ensures analytical focus on the most research-intensive MNCs while maintaining a manageable dataset for detailed network analysis.

While this criterion may introduce selection bias toward highly R&D-intensive sectors, this bias is consistent with the study's objective: to analyze collaboration dynamics among the most significant private R&D performers in Europe. The implications of this selection are discussed as methodological limitations below.

The resulting dataset includes 50 parent companies and 411 subsidiaries, accounting for 6,645 participations across three Framework Programmes and forming a large-scale collaborative network of substantial technological and financial relevance.

3.5. Size and sectoral considerations

Company size was not controlled for, particularly at the subsidiary level. This methodological choice reflects the study's focus on network structure and cross-border knowledge flows rather than firm-level characteristics.

Sectoral heterogeneity was also intentionally not controlled for. Allowing sectoral variation to emerge organically from the network reflects the real diversity of R&D strategies across industries and avoids imposing exogenous structure on collaboration patterns. This approach also enables the identification of sector-driven dynamics within the network.

3.6. Regression approach and limitations

The regression analysis employs simple linear models. This choice is justified by the exploratory nature of the study, which seeks to identify preliminary associations between internal collaboration and network centrality rather than establish causal relationships. Given the modest number of parent companies (n=50), the inclusion of extensive covariates would risk overfitting. Nevertheless, the inclusion of at least one control variable (sector type) has now been considered and incorporated where appropriate.

Finally, we acknowledge several methodological limitations: the sample's focus on top R&D investors, the exclusive use of publicly funded collaborations, and the constraints imposed by organization-level harmonization procedures. These limitations do not compromise the validity of the findings but should be taken into account when interpreting them.

3.7. Variables under study

From this empirical base, two interrelated networks are modelled and examined. The first captures the direct participation of parent companies in Framework Programme projects. The second incorporates the relationships between parent companies and subsidiaries, highlighting cases of joint participation and their implications for the overall structure of the network.

The methodological proposal focuses on examining the position of MNCs within the collaboration network established through the European Framework Programmes. To this end, a network analysis is applied, using centrality measures for each node of the network and deriving the main characteristics of the global structure. To address the research objective and test the hypothesis, two different networks are explored: (i) global collaboration network: refers to the network formed by the collaborations established in the three Framework Programmes among the 461 companies (nodes). Links correspond to the existence of a joint R&D&I project funded under these programmes, and (ii) group-level collaboration network: for each multinational (parent company) analyzed, this refers to the network formed by the collaborations between the parent and its subsidiaries.

To analyse these networks, four centrality indicators are calculated for each node, enabling a systematic assessment of collaboration patterns and the strategic position of firms within the European R&D landscape.

The centrality measures considered in this study are based on Cerqueti et al. (2024), who in turn build on the work of Scott and Carrington (2011).

- **Degree Centrality (k):** defined as the number of links a node has. In this analysis, it is interpreted as the extent to which a participating company is directly connected to others, representing its overall level of collaborative activity.
- **Closeness Centrality (CC):** measures how close a node is to all other nodes in the network. This value reflects the natural distance between all pairs of nodes, defined by the length of their shortest paths. It represents how easily a node can reach others without the need for direct links.
- **Betweenness Centrality (BC):** measures the number of times a node acts as a bridge along the shortest path between two other nodes. In this context, it captures the ability of a company to serve as a connector between organizations that do not collaborate directly in R&D&I projects.
- **Eigenvector Centrality (EC):** represents the importance of a node in the network according to both the number and the quality of its connections. It is interpreted as an indicator of structural influence.

In addition, other indicators are provided to characterize the overall collaboration network: average degree, network diameter, average path length, graph density, average clustering coefficient, and modularity (Yang, 2024; Newman, 2006; Camacho, 2020).

To test the hypothesis, the following must be verified: business groups with higher levels of internal collaboration exhibit higher centrality values in the global network. To approximate this hypothesis, simple linear models are proposed as follows:

$$Average\ centrality_k = \beta_0 + \beta_1 * Density + \varepsilon$$

where β_0 is the intercept, β_1 the coefficient of the independent variable (density), and ε the error term. *Density* refers to the level of collaboration density within the business group. *Average centrality* is the dependent variable, with k=1 for degree centrality, k=2 for closeness centrality, k=3 for betweenness centrality, and k=4 for eigenvector centrality.

4. Results

4.1. Behavioral Analysis

Behavioral indicators of parent multinational companies:

Out of the parent companies analyzed, 74% participated at least once in any Framework Programme (Indicator 01). Of this 74%, 73% (Indicator 02) coordinated at least one collaborative R&D&I project within these Framework Programmes. The sample of parent companies generates a collaboration system comprising 2,325 participations and a total net EU contribution of €1,111,370,093.14.

Regarding the distribution of the net EU contribution (Indicator 03), over 90% is allocated to parent companies from Germany, the Netherlands, and France. It is also observed that parent companies from some countries maintain continuous participation across the three Framework Programmes, while others, such as Ireland and Belgium, do not show this continuity. A similar pattern emerges when analyzing participation (Indicator 04), with 80% of participations concentrated among parent companies from Germany, France, and the Netherlands.

The intensity of EU funding relative to R&D investment (Indicator 05) is 13.5%, indicating that the total net EU contribution over the three Framework Programmes represents 13.5% of the total R&D investment of all selected parent companies. Based on the R&D investment data reported in the EU Industrial R&D Investment Scoreboard for each year, the net EU contribution in the Framework Programmes is calculated as a percentage of each parent company's R&D investment, yielding an average value of 0.1% (Indicator 06). Indicator 07 calculates the net EU contribution by country as a percentage of the total net EU contribution to that country (including all participations). For example, German parent companies in the sample received 2.37% of the total EU contribution to companies in Germany across the three Framework Programmes. Overall, these values are relatively low, indicating that multinational parent companies do not represent a significant share of these programmes in terms of monetary contribution.

Behavioral indicators of parent companies – subsidiaries:

Of all parent companies in the sample, 50% have at least one subsidiary established in the same country as the parent that participates in the studied Framework Programmes (Indicator 08), while 72% of parent companies have at least one subsidiary established abroad with participation in these programmes (Indicator 09). Additionally, 46% of parent companies have subsidiaries both in the same country and abroad that participate in the EU Framework Programmes (Indicator 10). Indicator 15 shows that 66% of the parent companies collaborate with subsidiaries of the same business group in the Framework Programmes (at least one collaboration with a subsidiary). These indicators provide evidence of global technology generation through global technological collaboration.

4.2. Network Analysis

This section presents the results derived from the network analysis applied to the study dataset, comprising 461 nodes (parent companies and subsidiaries) and 2,785 edges, corresponding to the joint participation of two nodes in a collaborative R&D&I project funded by the EU within the Framework Programmes. Key network indicators were calculated using Gephi software.

General characteristics of the network:

Table 2 shows the indicators that characterize the network. The network has an average collaborative activity level of 12 collaborations per node. However, 81 nodes (17.57% of entities) have no connections with other entities, while the maximum number of connections is 103, indicating that the average collaborative activity is relatively low.

The network diameter indicates that the two most distant connected nodes are eight edges apart. A diameter of 8 in a network of 461 nodes suggests a relatively well-connected network. Complementing this with the average path length suggests a compact network, where paths between node pairs are short despite the network's size. The difference of 5 points between the maximum distance and the average path length indicates the existence of well-connected communities, facilitating rapid connections.

This characteristic is supported by the modularity indicator, which reflects the extent to which the network is divided into communities. The network in this study, with a modularity value of 0.494, shows detectable subgroups, although with substantial inter-community connections. The average clustering coefficient indicates the number of triangles formed in the network, reflecting the formation of local clusters. A value of 0.649 demonstrates high local cohesion, typical of collaborative networks.

Table 2. General characteristics from the network (Own elaboration from data extracted from Gephi).

Indicator	Value	Range
Average degree centrality	12,082	[0, ∞]
Network diameter	8	[0, ∞]
Average path length	2,818	[0, ∞]
Graph density	0,026	[0,1]
Average clustering coefficient	0,649	[0,1]
Modularity	0,494	[0,1]

After analyzing the general network data, it can be concluded that the network exhibits low density, high connection efficiency (short average path length), and significant local cohesion, along with the presence of communities. These are characteristics typical of the "small-world" phenomenon (Watts & Strogatz, 1998).

<u>Centrality indicators:</u>

For the graphical representation of the network, the ForceAtlas algorithm, a force-directed layout, was selected. This algorithm allows for a clear visualization of connected nodes attracting each other, while unconnected nodes repel one another. The four centrality indicators are represented as follows:

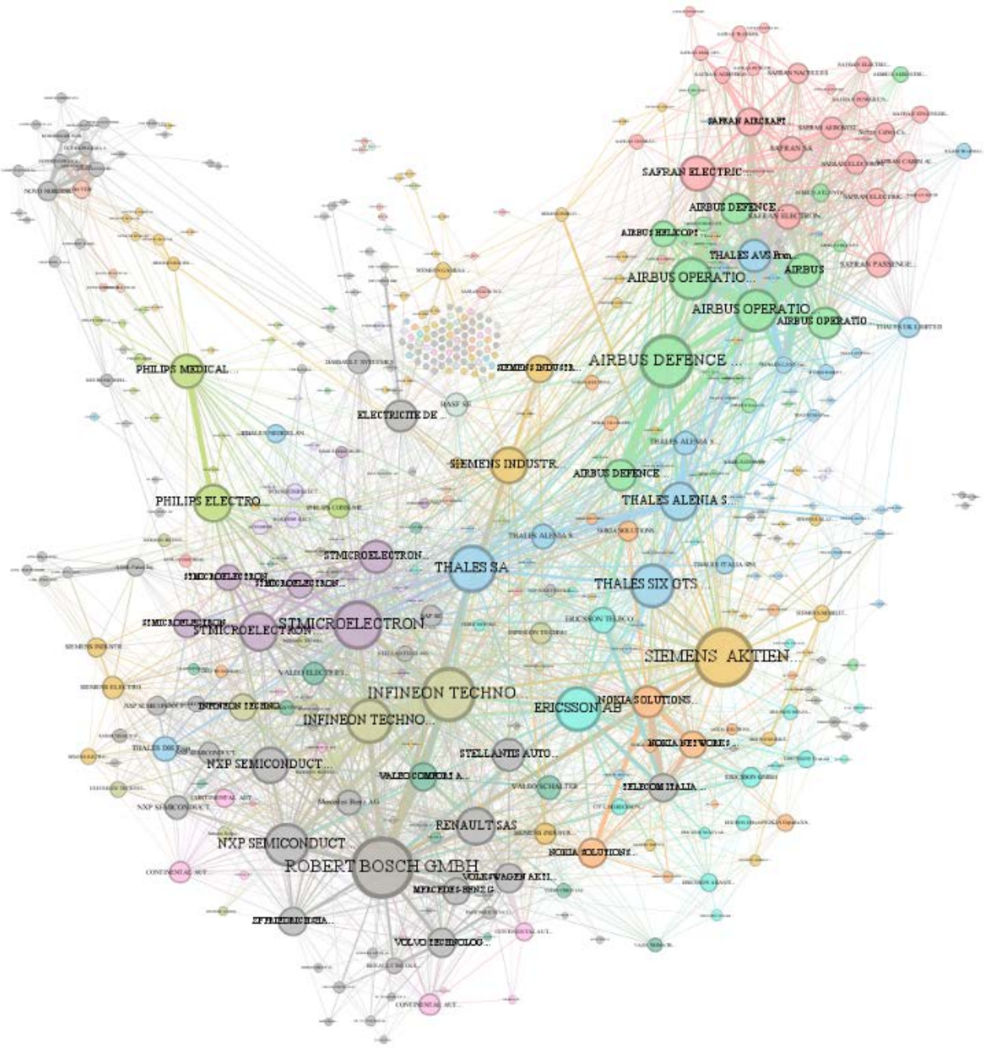
Degree centrality: Many nodes have a small number of connections, and as the number of connections increases, the number of nodes decreases. In the ranking of entities by degree centrality, shown in Table 3, two subsidiaries appear in the highest positions of collaborative activity, although the top three positions are occupied by parent companies from highly technological sectors.

Table 3. Ranking of entities by Degree Centrality indicator (Own elaboration).

ID	Entity	Industry	Grade
M04	ROBERT BOSCH GMBH	Automobiles and Parts	103
M08	SIEMENS AKTIENGESELLSCHAFT	Electrical and Electronic Equipment	97
M25	INFINEON TECHNOLOGIES AG	Technology Equipment and Hardware	89
M15S19	AIRBUS DEFENCE AND SPACE GMBH	Aerospace and Defense	87
M33S08	STMICROELECTRONICS SRL	Technology Equipment and Hardware	79

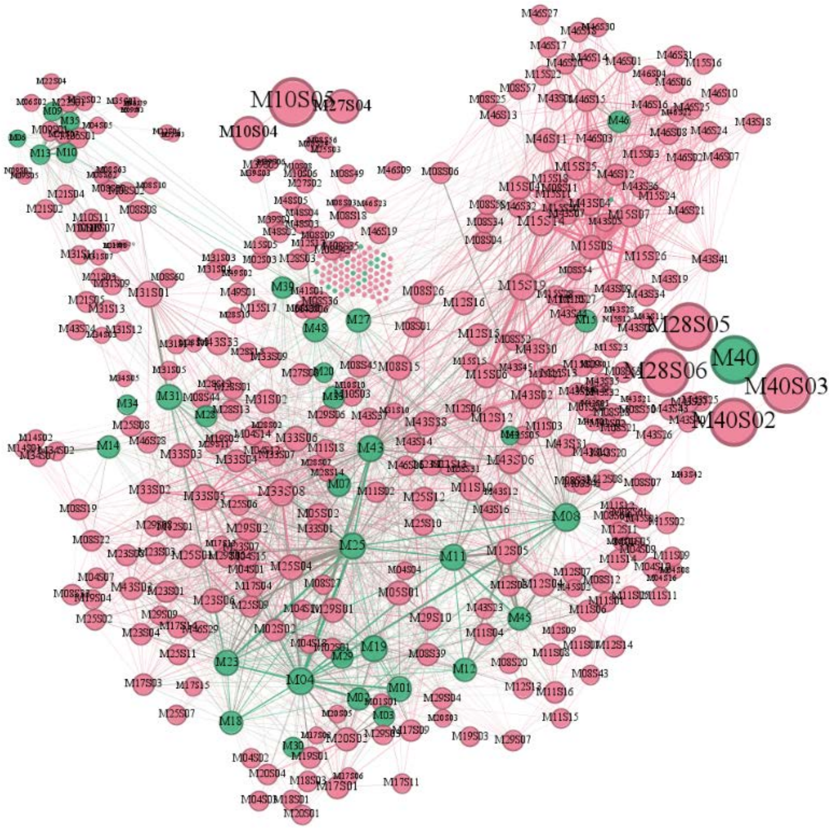
Figure 1 reinforces the interpretation of the network's degree distribution. It shows the distribution of the corporate groups forming the network, the existence of global technology generation through global technological collaboration, and the importance of certain nodes in terms of net collaborative activity. Additionally, it can be observed that some corporate groups form their own compact collaboration networks, such as Safran, Airbus, or STMicroelectronics, while other groups are more dispersed within the network, including Ericsson, Thales, and Siemens.

Figure 1. Network visualization with ForceAtlas algorithm. Node size represents Degree.
Colors classified by Business Group. (Own elaboration with Gephi)



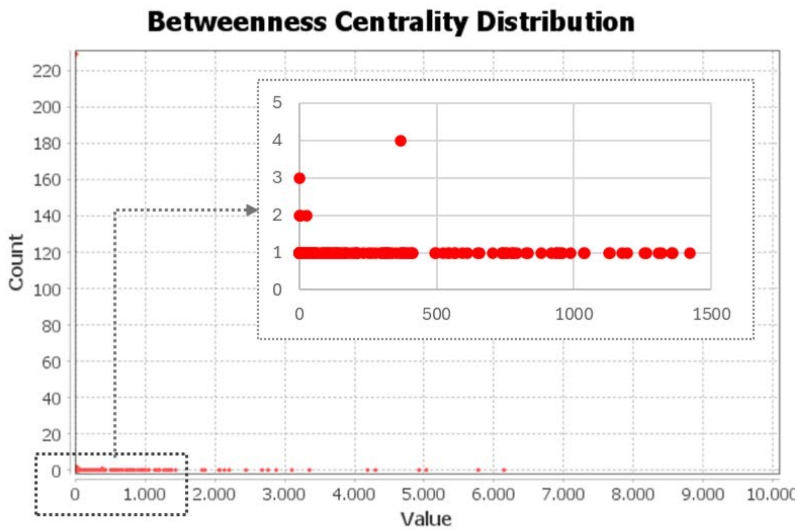
Closeness Centrality indicator: nodes without collaboration with others have a closeness centrality equal to zero. Among the remaining nodes in the network, closeness values are very similar and cluster around 0.3, except for six entities that stand out with a closeness centrality of 1. Of these six entities, only one is a parent company. Figure 2 illustrates the analysis of closeness centrality, reflecting the uniformity of closeness values and the leadership of the six entities. An important finding in this distribution is that these six leading entities do not have many participations and do not act as intermediary nodes.

Figure 2. Network visualization with ForceAtlas algorithm. Node size represents Closeness centrality. Colors: green – parent company; pink – subsidiary. (Own elaboration with Gephi)



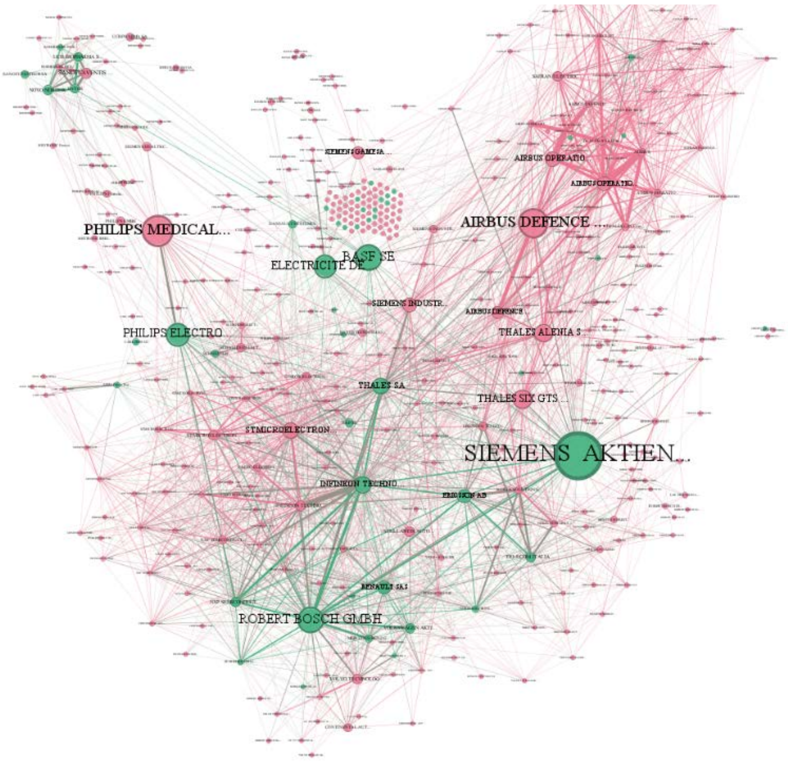
Betweenness Centrality indicator: In the analyzed network, as shown in Figure 3, 49.89% of the nodes do not act as bridges, and their betweenness centrality is zero. Another large proportion of the sample (43.16%) has a centrality value concentrated in the range of 100–1000, meaning that very few nodes (6.95% of the sample) function in this capacity.

Figure 3. Distribution of intermediation centrality (Source: Gephi)



It is clearly observed that many nodes in the network do not have a dominant position in terms of betweenness centrality, and parent companies lead this indicator (Figure 4). Nevertheless, as mentioned, some subsidiaries stand out as connecting bridges, such as Airbus Defence and Space GmbH and Philips Medical Systems Nederland BV. Indeed, in the aerospace and defense sector (upper right area of the illustration) and in the pharmaceutical sector (upper left area), connections between nodes that are otherwise unconnected occur through subsidiaries.

Figure 4. Network visualization with ForceAtlas algorithm. Node size represents Betweenness centrality.
Colors: green – parent company; pink – subsidiary. (Own elaboration with Gephi)



Eigenvector Centrality: It is observed that both parent companies and subsidiaries hold importance in the formed collaboration network, although the ranking is led by parent companies, as shown in Table 4. Notably, three of the five top entities in this ranking are located in the second half of the EU Industrial R&D Investment Scoreboard – 2024.

Figure 5. Network visualization with ForceAtlas algorithm. Node size represents Eigenvector centrality.
Colors: green – parent company; pink – subsidiary. (Own elaboration with Gephi)

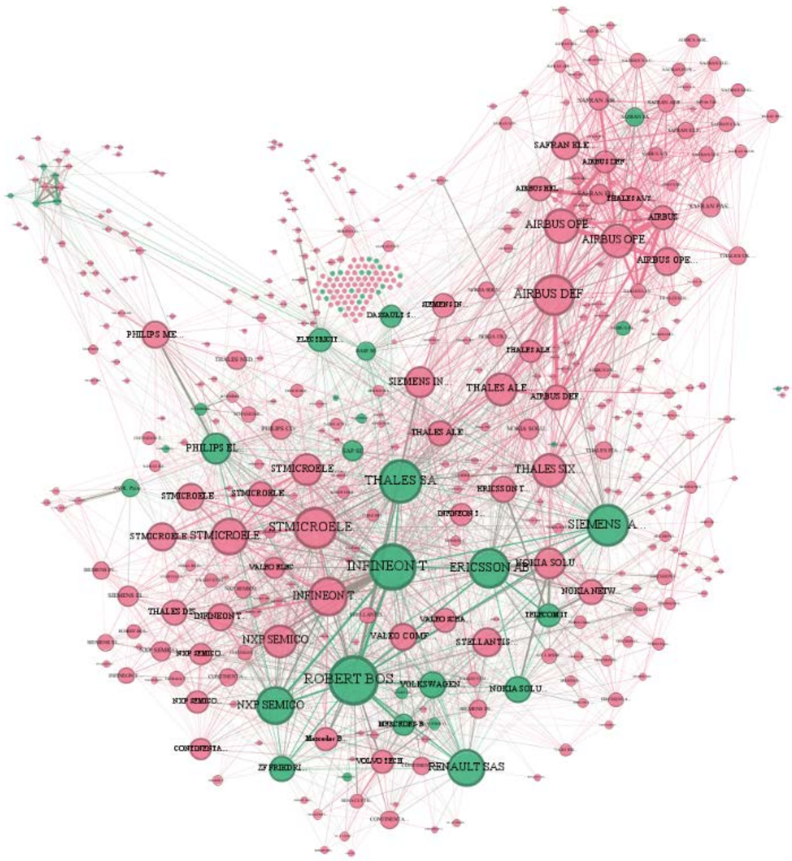


Table 4. Ranking of entities by Eigenvector Centrality (Source: Own elaboration)

ID	Entity	Industry	Eigenvector centrality
M04	ROBERT BOSCH GMBH	Automobiles and Parts	1
M25	INFINEON TECHNOLOGIES AG	Technology Equipment and Hardware	0.945059
M43	THALES SA	Aerospace and Defence	0.866047
M33S08	STMICROELECTRONICS SRL	Technology Equipment and Hardware	0.851032
M08	SIEMENS AKTIENGESELLSCHAFT	Electrical and Electronic Equipment	0.835076

Regarding the proposed hypothesis, Table 5 presents the results of this analysis. The average centrality for each of the indicators and the density of each corporate group have been calculated.

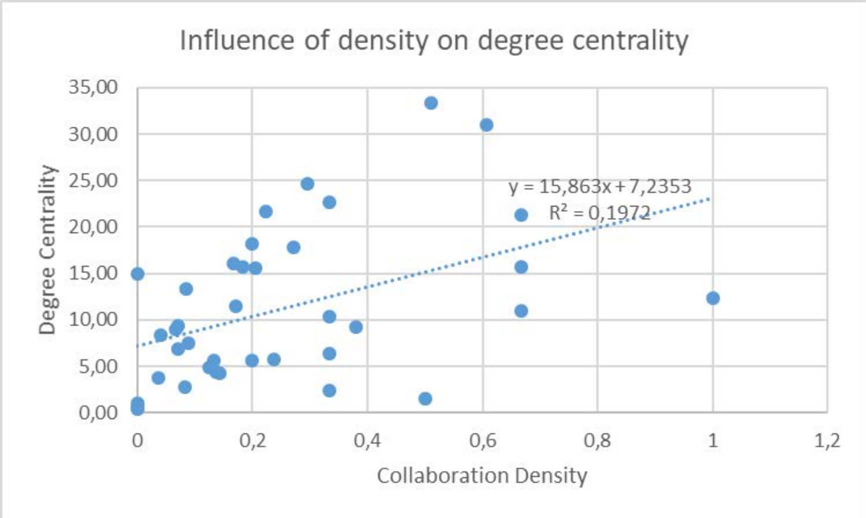
Table 5. Corporate Group network characteristics. Own elaboration from data extracted from Gephi.

Corporate Group	Nodes	Maximum Links	Density	Degree Centrality	Closeness Centrality	Betweenness Centrality	Eigenvector Centrality
ASML	3	3	1	12,3333	0,3649	123,0051	0,1287
MERCEDES	4	6	0,667	21,2500	0,3861	238,9415	0,2244
SANOFI	3	3	0,667	11,0000	0,3183	721,6015	0,0285
TELECOM	3	3	0,667	15,6667	0,3633	391,3242	0,1550
NXP	8	28	0,607	31,0000	0,4093	308,5918	0,3761
STMICROELECTRONICS	10	45	0,511	33,3000	0,4316	585,3013	0,4118
UBISOFT	4	6	0,5	1,5000	0,7500	0,0000	0,0005
EDF	7	21	0,381	9,2857	0,2987	596,8298	0,0710
CNH	3	3	0,333	2,3333	0,2130	124,1987	0,0283
STELLANTIS	3	3	0,333	22,6667	0,2958	468,1750	0,2747
UCB	3	3	0,333	6,3333	0,2007	622,4587	0,0091
VOLVO	6	15	0,333	10,3333	0,3547	221,7647	0,1032
INFINEON	13	78	0,295	24,6154	0,3982	364,3605	0,3029
SAFRAN	33	528	0,271	17,8182	0,3567	114,6446	0,1736
DASSAULT	7	21	0,238	5,7143	0,2350	175,7838	0,0656
AIRBUS	29	406	0,224	21,6552	0,3801	542,6627	0,2147
ERICSSON	19	171	0,205	15,6316	0,3645	225,7577	0,1692
MEDTRONIC	6	15	0,2	5,6667	0,2377	109,4296	0,0354
RENAULT	5	10	0,2	18,2000	0,3878	426,1493	0,2136
NOKIA	18	153	0,183	15,7222	0,3510	132,2992	0,1933
PHILIPS	15	105	0,171	11,4667	0,3266	873,0787	0,1109
VALEO	12	66	0,167	16,0833	0,3908	162,5588	0,2112
MERCK	8	28	0,143	4,2500	0,2114	53,7492	0,0080
BAYER	12	66	0,136	4,3333	0,3555	175,9556	0,0159
BOEHRINGER	6	15	0,133	5,6667	0,2229	89,8759	0,0101
SCHNEIDER	16	120	0,125	4,9375	0,3533	135,2910	0,0419
CONTINENTAL	17	136	0,088	7,4706	0,2087	78,2026	0,0865
THALES	46	1035	0,084	13,3478	0,3392	295,0381	0,1484
CARL ZEISS	9	36	0,083	2,7778	0,1759	62,6525	0,0207
VOLKSWAGEN	8	28	0,071	6,8750	0,1872	196,5043	0,0736
BOSCH	19	171	0,07	9,3684	0,2974	270,3684	0,1033
ZF	6	15	0,067	9,0000	0,1933	53,7505	0,1078
SIEMENS	64	2016	0,041	8,4063	0,2928	288,6367	0,0810
BASF	11	55	0,036	3,7273	0,1667	457,4679	0,0364
ACCENTURE	5	10	0	0,4000	0,0649	0,0000	0,0026
AMADEUS	2	1	0,0000	1,0000	0,3134	0,0000	0,0128
APTIV	4	6	0,0000	0,5000	0,1523	0,0000	0,0059
SAP	2	1	0	15,0000	0,2232	467,4140	0,1822

Observing the obtained graphs, it appears that collaboration density does not clearly explain the variability of the dependent variables. All four linear regressions have R^2 values below 0.3. It can be concluded that there is no association between high collaboration density and centrality in the network; in other words, the internal collaboration density among the nodes of the same corporate group does not seem to be a determining factor in explaining a central position (higher centrality indicators) in the collaboration network.

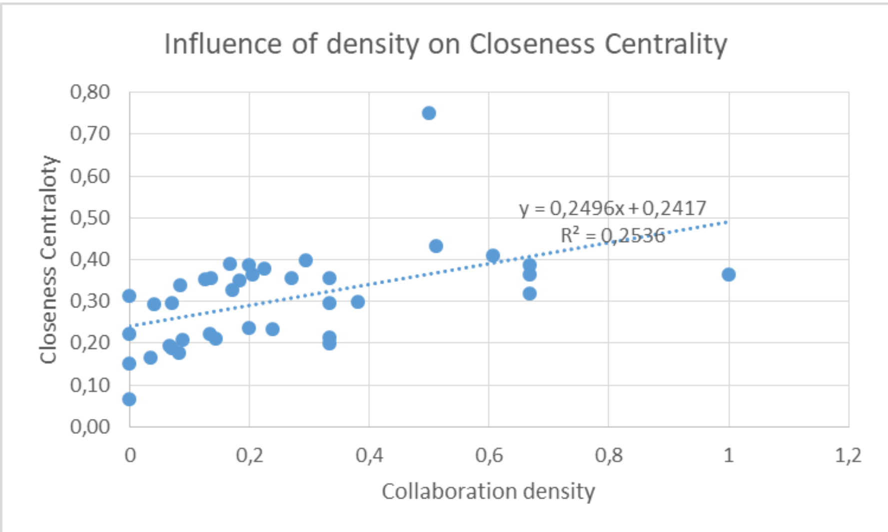
These linear relationships provide a simple approximation that does not establish a clear association between the independent and dependent variables. However, by analyzing the obtained coefficients, a positive relationship between the two can be observed, along with trends that warrant further investigation, such as the inclusion of control variables in the model.

Figure 6. Relationship between collaboration density and degree centrality by business group (Own elaboration)



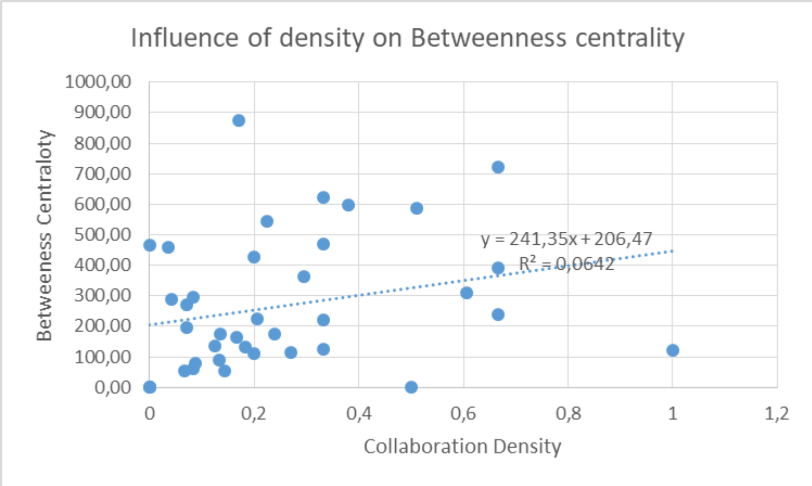
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	500,132707	500,132707	8,84076226	0,00522887
Residual	36	2036,56392	56,57122		
Total	37	2536,69663			

Figure 7. Relationship between collaboration density and closeness centrality by business group (Own elaboration)



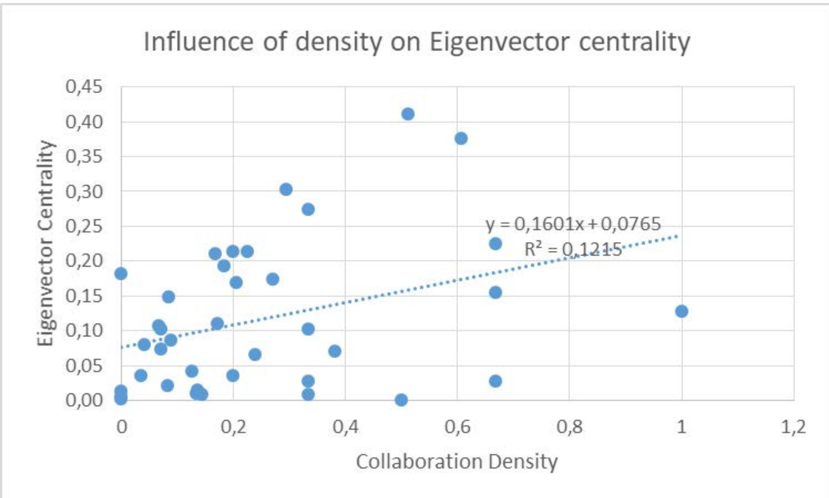
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,1238275	0,1238275	12,2320124	0,00126804
Residual	36	0,36443635	0,01012323		
Total	37	0,48826385			

Figure 8. Relationship between collaboration density and betweenness centrality by business group (Own elaboration)



ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	115781,667	115781,667	2,470166	0,12477444
Residual	36	1687392,68	46872,0188		
Total	37	1803174,34			

Figure 9. Relationship between collaboration density and eigenvector centrality by business group (Own elaboration)



ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,05094892	0,05094892	4,97689788	0,03200869
Residual	36	0,36853498	0,01023708		
Total	37	0,41948389			

5. Discussion and conclusions

The phenomenon of techno-globalism, supported by the expansion of information and communication technologies, has removed geographical barriers and allowed the effective transfer of knowledge and technology worldwide. Technological globalization appears in the global ecosystem in different forms: global technology exploitation, global technology collaboration, and global technology generation. While the first two forms can involve multiple actors such as universities, startups, public administrations, and research centers, global technology generation is mainly a characteristic of multinational corporations (MNCs).

In this context of technological internationalization, MNCs occupy a unique and exceptional position in the global R&D landscape. They have the ability to combine different forms of technological globalization in their strategies. To assess the existence of this combination, this study analyzes the participation of multinational companies in recent European Union (EU) Framework Programmes (FPs) and examines how parent companies (matrices) and their subsidiaries interact within the same corporate group.

The analysis follows two complementary approaches. First, participation indicators are used to identify patterns in the behavior of MNCs and the factors influencing their use of global technology collaboration. Second, a network analysis of the collaboration generated by these interactions is conducted, calculating centrality indicators for all entities and examining in detail the connections between parent companies and subsidiaries.

5.1. Key Findings on Participation

One of the main conclusions is that European MNCs widely use EU public R&D collaboration programmes. However, parent company participation is concentrated in central European countries or in countries with favorable tax conditions and supportive frameworks for R&D activities. Expanding the study to subsidiaries with the same commercial name as parent companies shows the geographical dispersion of R&D activities, confirming the existence of global technology generation by multinational firms.

Analysis of participation highlights that EU funding represents only a small portion of these companies' total R&D investment. This suggests that MNCs participate not primarily for funding, but for the collaboration itself, which provides access to external strategic knowledge and technology. Categorization by country confirms that the largest industrial firms investing in technological development receive a minimal share of public support compared to other actors in the innovation ecosystem. Therefore, the financial contribution from the EU does not appear to be the main motivation for MNC participation.

A direct association is observed between the number of awarded projects and collaborations and between the number of projects and the total funding received. However, the link between increased participation and higher funding remains unclear, as seen in the comparison by country of participation and EU contribution across different FPs. Data on EU net contributions and participation indicate the leadership of central European countries, likely influenced by the selection of the sample. In other words, parent companies from these countries are among the largest investors in R&D, according to the 2024 EU Industrial R&D Investment Scoreboard.

Sectoral analysis shows which industries receive the most investment from Europe and identifies historically competitive sectors, such as the automotive industry, as well as other highly technological sectors. Geographic distribution analysis highlights the delocalization of R&D activities through subsidiaries. Subsidiaries outside the parent company's country often have broader collaboration and funding networks than subsidiaries located in the same country as the parent, reflecting the higher number of foreign subsidiaries included in the sample.

5.2. Network Analysis Insights

Network analysis reveals that the collaboration network formed by parent companies and subsidiaries in the Framework Programmes has typical features of a collaborative network. However, network potential is not fully exploited due to low density. Two possibilities may explain this: entities may choose to work only with specific partners, or the return from EU R&D funding may be too small relative to their investment, discouraging further exploitation of the network.

Despite low density, the network demonstrates strong cohesion. Entities can easily connect through the network, and the network exhibits the "small world" phenomenon, indicated by a short average path length and a high clustering coefficient. In practical terms, this means that although the network contains many nodes, most nodes belong to communities that allow rapid connection with others, resulting in very short distances between nodes.

The analysis also reveals differences between parent companies and subsidiaries in some network indicators. Subsidiaries are highly connected within local collaboration systems; a subsidiary collaborates with the partners of its collaborators, as reflected in high clustering indicators. This underscores the importance of subsidiaries in acquiring knowledge and technology in local and regional ecosystems. Both parent companies and subsidiaries show similar behavior for eigenvector centrality, indicating that both types of entities are important in the network due to the connections they establish and their closeness centrality. Parent companies, however, generally play a greater role in betweenness centrality, though some subsidiaries also act as key intermediaries when participating in multiple projects.

5.3. Parent–Subsidiary Collaboration

Regarding parent–subsidiary behavior, internal collaboration within a corporate group does not appear to determine the group's central position in the collaboration network. In other words, the existence of global technology collaboration for global technology generation does not decisively influence the MNC's importance in terms of R&D collaboration capabilities within EU Framework Programmes. Therefore, the hypothesis is not confirmed by the results of this study. Although some patterns suggest that internal collaboration between headquarters and subsidiaries may contribute to a stronger position within the network, the evidence is neither strong nor consistent enough to support the hypothesis.

It is also important to acknowledge that multinational enterprises are not the primary target group of the EU Framework Programmes, which were originally designed to support public research organisations, universities, and innovative SMEs. As a result, MNEs tend to engage in these programmes with strategic objectives that extend beyond the internal dynamics of their corporate network. Their participation patterns are often shaped by external drivers—such as technological positioning, access to scientific communities, regulatory alignment, or the search for complementary capabilities—rather than by internal collaboration density alone. These structural differences may partly explain why the expected relationship between internal collaboration and network centrality does not emerge clearly in our empirical analysis.

Future research with more granular data on intra-firm networks and additional controls for firm-specific strategies may shed further light on these relationships.

The network clearly shows the formation of communities composed of entities from different but related sectors. This may be due to the nature of the Framework Programmes, which require consortia of multidisciplinary teams working in specific research areas. Notably, collaboration communities typically include participants from more than three countries. However, belonging to the same corporate group or sector does not imply membership in a single community; companies from the same sector may be in different communities, and entities from the same MNC may also belong to separate clusters.

5.4. Contributions and Implications

This study deepens research on technology internationalization, detailing the behavior of MNCs in a relatively unexplored context: EU Framework Programmes. Beyond contributing to the literature on technological globalization, it provides insights for integrating MNCs into studies of public R&D funding and collaboration networks. The analysis helps identify variables and attributes that improve an entity's position within the R&D collaboration ecosystem.

From a policy perspective, the results offer information for optimizing EU funding distribution, identifying MNCs as connection hubs to less engaged entities, or recognizing entities that aggregate funds and create dependency or concentration of power. Academically, the behavior and network analysis framework presented here is replicable and can be applied to study parent–subsidiary relationships in other programs, regions, or countries.

5.5. Limitations and Future Research

This research has limitations. First, data availability and accuracy on EU platforms are not perfect. Duplicate records exist, and structural changes like company closures, mergers, or acquisitions were not considered; the study assumes data as accurate at the time of writing. Future research should account for such processes.

Further studies could examine R&D collaboration across an entire corporate group, including subsidiaries with different commercial names. This analysis focuses on parent–subsidiary pairs sharing the same commercial name, but MNCs often have hierarchical structures with multiple controlled companies, each with different R&D processes and strategies. A dynamic network analysis over time could show how collaboration evolves across different Framework Programmes. Additionally, sector-focused studies or collaboration type analyses (research vs. innovation) would complement this work. Applying taxonomies like Zander (1999) to studied MNCs could also enrich the analysis. Incorporating MNCs into collaboration networks with universities, research centers, or SMEs is another valuable direction.

5.6. Final Remarks

Overall, this study provides relevant evidence of multinational participation in EU Framework Programmes, highlighting their key role and establishing a foundation for deeper analysis of participation motivation and influence within collaborative networks. It contributes both to understanding MNC behavior in public R&D programmes and to methodological approaches for studying complex parent–subsidiary interactions in international R&D networks.

References

Almendral, J., Oliveira, J., López, L. & Mendes, J. F. & Sanjuán, M. (2009). The Network of Scientific Collaborations within the European Framework Programme. *Physica A: Statistical Mechanics and its Applications.* 384(2), 675-683. 10.1016/j.physa.2007.05.049.

Amoroso, S., Coad, A., & Grassano, N. (2020). European R&D networks: a snapshot from the 7th EU Framework Programme. In *Assessing Technology and Innovation Policies* (pp. 8-23). Routledge. 10.1080/10438599.2017.1374037

Archibugi, D., & Michie, J. (1995). The globalisation of technology: a new taxonomy. *Cambridge journal of Economics*, *19*(1), 121-140. https://doi.org/10.1093/oxfordjournals.cje.a035299

Audretsch, D. B., & Belitski, M. (2024). Knowledge collaboration, firm productivity and innovation: A critical assessment. *Journal of Business Research,* 172, 114412. https://doi.org/10.1016/j.jbusres.2023.114412

Balland, P. A., Boschma, R., & Ravet, J. (2019). Network dynamics in collaborative research in the EU, 2003–2017. *European Planning Studies*, *27*(9), 1811-1837. 10.1080/09654313.2019.1641187

Belderbos, R., Leten, B., & Suzuki, S. (2023). International R&D and MNCs' innovation performance: An integrated approach. *Journal of International Management*, *29*(6), 101083. https://doi.org/10.1016/j.intman.2023.101083

Belderbos, René & Carree, Martin & Lokshin, Boris. (2004). Cooperative R&D and Firm Performance. Research Policy. 33. 1477-1492. https://doi.org/10.1016/j.respol.2004.07.003

Belitz, H. (2010). R&D Internationalization in Multinational Corporations: Some Recent Trends. In: Gerybadze, A., Hommel, U., Reiners, H., Thomaschewski, D. (eds) *Innovation and International Corporate Growth*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-10823-5_4

Børing, P., Fevolden, A. M., Mark, M. S., & Piro, F. N. (2019). Bringing home the bacon: the relationship between firm characteristics and participation in EU Horizon 2020 projects. *Applied Economics Letters*, 27(19), 1556–1561. https://doi.org/10.1080/13504851.2019.1696932

Breschi, S., & Cusmano, L. (2006). Unveiling the texture of a European Research Area: emergence of oligarchic networks under EU Framework Programmes. *In Knowledge flows in European industry (*pp. 294-324). Routledge. http://dx.doi.org/10.1504/IJTM.2004.004992

Calignano G. Better connected, more reputable? On the association between node centrality and academic reputation in the European Union research and innovation networks. *Eur Policy Anal*. 2021; 7: 240–262. https://doi.org/10.1002/epa2.1079

Camacho, D., Panizo-LLedot, A., Bello-Orgaz, G., Gonzalez-Pardo, A., & Cambria, E. (2020). The four dimensions of social network analysis: An overview of research methods, applications, and software tools. *Information Fusion*, *63*, 88-120 https://doi.org/10.1016/j.inffus.2020.05.009

Cantwell, J. (1989). Technological innovation and multinational corporations. In *Oxford and Cambridge, Mass.: Blackwell, 1989, pp. xvi, 239* (pp. xvi–xvi).

Cerqueti, R., Iovanella, A. & Mattera, R. Clustering networked funded European research activities through rank-size laws. *Ann Oper Res* 342, 1707–1735 (2024). https://doi.org/10.1007/s10479-023-05321-6

Cherif, R., Grimpe, C., Hasanov, F. et al. Promoting Innovation: The Differential Impact of R&D Subsidies. *J Ind Compet Trade* 23, 187–241 (2023). https://doi.org/10.1007/s10842-023-00400-7

Cohen, Maria & Fernandes, Gabriela & Godinho, Pedro. (2024). Measuring the impacts of university-industry R&D collaborations: a systematic literature review. *The Journal of Technology Transfer*. 50. 345-374. 10.1007/s10961-024-10114-5

Ćudić, B., Alešnik, P. & Hazemali, D. Factors impacting university–industry collaboration in European countries. J Innov Entrep 11, 33 (2022). *https://doi.org/10.1186/s13731-022-00226-3*

Dachs, B., Amoroso, S., Castellani, D., Papanastassiou, M., & von Zedtwitz, M. (2024). The internationalisation of R&D: Past, present and future. *International Business Review*, *33*(1). https://doi.org/10.1016/j.ibusrev.2023.102191

Du, J., Zhu, S. & Li, W.H. Innovation through internationalization: A systematic review and research agenda. *Asia Pac J Manag* **40**, 1217–1251 (2023). https://doi.org/10.1007/s10490-022-09814-z

Enger, S. G. (2018). Closed clubs: Network centrality and participation in Horizon 2020. *Science and Public Policy*, *45*(6), 884-896. https://doi.org/10.1093/scipol/scy029

Enger, S. G. (2020). The Factors Behind Participation: Evidence from the European Framework Programme, Horizon 2020. http://urn.nb.no/URN:NBN:no-75442

Enger, S.G., Castellacci, F. (2016). Who gets Horizon 2020 research grants? Propensity to apply and probability to succeed in a two-step analysis. *Scientometrics* 109, 1611–1638 https://doi.org/10.1007/s11192-016-2145-5

Etzkowitz, Henry. (2003). Innovation in Innovation: The Triple Helix of University-Industry-Government Relations. *Social Science Information Sur Les Sciences Sociales* - SOC SCI INFORM. 42. 293-337. 10.1177/05390184030423002

European Commission (2025). EU Funding & Tenders Portal. https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/home
(retrieved September 8th, 2025)

European Commission (2025). CORDIS - EU research results https://cordis.europa.eu/ (retrieved September 8th, 2025)

European Commission (2025) Horizon Dashboard. https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/horizon-dashboard (retrieved September 8th, 2025)

Ferrer-Serrano, M., Latorre-Martínez, M.P. & Fuentelsaz, L. (2021). The European research landscape under the Horizon 2020 Lenses: the interaction between science centers, public institutions, and industry. *J Technol Transf* 46, 828–853. https://doi.org/10.1007/s10961-020-09816-3

Garas, A., & Argyrakis, P. (2008). A network approach for the scientific collaboration in the European Framework Programs. *EPL (Europhysics Letters), 84*(6), 68005. https://doi.org/10.1209/0295-5075/84/68005.

Gerybadze, A., & Reger, G. (1999). Globalization of R&D: recent changes in the management of innovation in transnational corporations. *Research policy*, *28*(2-3), 251-274. https://doi.org/10.1016/S0048-7333(98)00111-5

Giannopoulou, Eleni & Barlatier, Pierre-Jean & Pénin, Julien. (2019). Same but different? Research and technology organizations, universities and the innovation activities of firms. Research Policy. 48. 223-233. *10.1016/j.respol.2018.08.008.*

Grevesen, C. W. (2001). *The internationalization of technological activity and R&D performance in multinational enterprises*. Rutgers The State University of New Jersey, Graduate School-Newark.

Hasanov, F., Cherif, R., Grimpe, C. & Sofka, W. (2022). Promoting Innovation: The Differential Impact of R&D Subsidies. *IMF Working Papers. 2022*. 1. 10.5089/9798400217968.001.

Hsu, C. W., Lien, Y. C., & Chen, H. (2015). R&D internationalization and innovation performance. *International business review*, *24*(2), 187-195. https://doi.org/10.1016/j.ibusrev.2014.07.007

Kosztyán, Z. T., Király, F., Katona, A. I., Csizmadia, T., & Fehérvölgyi, B. (2024). Analysis and prediction of the Horizon 2020 R&D&I collaboration network. *Expert Systems with Applications*, *255*, 124417. https://doi.org/10.1016/j.eswa.2024.124417

Lagerström, K., Schweizer, R., & Jakobsson, J. (2019). Building R&D capability in subsidiaries – conceptualization of a process perspective. *Multinational Business Review, 27*(1), 35-53. https://doi.org/10.1108/MBR-01-2018-000

Lalanne, M. and Meyer, N. (2024). Research and Innovation Collaboration Networks across EU Regions over 2014-2020. *Territorial Development Insights Series*, JRC136781, European Commission

Leung, T. Y., & Sharma, P. (2021). Differences in the impact of R&D intensity and R&D internationalization on firm performance–Mediating role of innovation performance. *Journal of Business Research*, 131, 81-91. https://doi.org/10.1016/j.jbusres.2021.03.060

Liang, X., Xing, Z., & Shi, Y. (2015). Origins and Trends of the Multinational's R&D Internationalisation Research-a Systematic Literature Review. In Proceedings of the 21st *International Conference on Industrial Engineering and Engineering Management 2014* (pp. 597-606). Atlantis Press.

Lundvall, B.-Å. (1993). User-Producer Relationships, National Systems of Innovation and Internationalization. In Foray, D.: Freeman, C. (eds.) (Ed.), *Technology and the Wealth of Nations*

M, Newman. (2006). Modularity and community structure in networks, *Proc. Natl. Acad. Sci.* U.S.A. 103 (23) 8577-8582, https://doi.org/10.1073/pnas.0601602103

Molica, F. and Marques Santos, A. (2024). In search for the best match. Complementarities between R&I funds across EU regions. *Territorial Development Insights Series*, JRC136780, European Commission.

Morea, F., Soraci, A., & De Stefano, D. (2024). Mapping leadership and communities in EU-funded research through network analysis. *2410.19556*.

Nindl, E., Napolitano, L., Confraria, H., Rentocchini, F., Fako, P., Gavigan, J. & Tuebke, A. (2024). The 2024 EU Industrial R&D Investment Scoreboard, *Publications Office of the European Unio*n, Luxemburgo, JRC140129. https://data.europa.eu/doi/10.2760/0775231

Paier, Manfred & Scherngell, Thomas. (2011). Determinants of Collaboration in European R&D Networks: Empirical Evidence from a Discrete Choice Model. *Industry and Innovation.* 18. 89-104. 10.1080/13662716.2010.528935.

Papanastassiou, M., Pearce, R., & Zanfei, A. (2020). Changing perspectives on the internationalization of R&D and innovation by multinational enterprises: A review of the literature. *Journal of International Business Studies*, *51*(4), 623–664. https://www.jstor.org/stable/48741332

Red IDI (2025). Programa Marco de I+D+I. https://www.redpoliticasidi.es/es/recursos/programas-financiacion-europeos/programa-marco (retrieved September 8th, 2025)

Ribeiro, L. C., Rapini, M. S., Silva, L. A., & Albuquerque, E. M. (2018). Growth patterns of the network of international collaboration in science. *Scientometrics*, *114*, 159-179. https://doi.org/10.1007/s11192-017-2573-x

Scherngell, T., & Barber, M. J. (2009). Spatial interaction modelling of cross-region R&D collaborations: Empirical evidence from the 5th EU framework programme. *Papers in Regional Science*, *88*(3), 531-547. https://doi.org/10.1111/j.1435-5957.2008.00215.x

Scott, J., & Carrington, P. J. (2011). The SAGE Handbook of Social Network Analysis. USA: SAGE Publications

Siedschlag, I., Zhang, X., & Smith, D. (2013). What determines the location choice of multinational firms in the information and communication technologies sector? *Economics of Innovation and New Technology*, *22*(6), 581–600. https://doi.org/10.1080/10438599.2013.783266

Szücs, F. (2020). Do research subsidies crowd out private R&D of large firms? Evidence from European Framework Programmes. *Research Policy*. 49. 10.1016/j.respol.2020.103923

Un, C. & Cuervo-Cazurra, Alvaro & Asakawa, Kazuhiro. (2008). R&D Collaborations and Product Innovation. *Journal of Product Innovation Management*. 27. 10.1111/j.1540-5885.2010.00744.x.

Vrontis, D., & Christofi, M. (2021). R&D internationalization and innovation: A systematic review, integrative framework and future research directions. *Journal of Business Research,* 128, 812-823. https://doi.org/10.1016/j.jbusres.2019.03.03

Watts, D., Strogatz, S. Collective dynamics of 'small-world' networks. *Nature* 393, 440–442 (1998). https://doi.org/10.1038/30918

Wirsich, Alexander & Kock, Alexander & Strumann, Christoph & Schultz, Carsten. (2016). Effects of University–Industry Collaboration on Technological Newness of Firms. *Journal of Product Innovation Management*. 33. 10.1111/jpim.12342

Yang, S. (2024). *Social Network Analysis in Action: Basic Methods and Applications* (1st ed. 2024.). Springer International Publishing. https://doi.org/10.1007/978-3-031-66661-2

Zander, Ivo, 1999. "How do you mean 'global'? An empirical investigation of innovation networks in the multinational corporation*," Research Policy, Elsevier, vol. 28(2-3), pages 195-213, March. https://doi.org/10.1016/S0048-7333(98)00113-9*