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Papers in Evolutionary Economic Geography

25.20

Utrecht University Human Geography and Planning

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Abstract

European innovation policy combines place-based and spatially blind instruments that operate under distinct logics. Building synergies between them requires not only regulatory alignment, but a better understanding of how economic actors interact across policy levels. This study examines how companies' participation in the European Framework Programmes (FP) influences their propensity to engage in regional R&D partnerships, supported by Cohesion Policy. We analyse longitudinal data on Valencian firms using inferential network analysis (i.e., Temporal Exponential Random Graph Models). Results indicate that FP beneficiaries are more active in regional tie formation than non-FP firms, especially when academic intermediaries are involved. Yet, they also tend to collaborate with each other, limiting opportunities for knowledge diffusion among firms that do not benefit from the international collaboration premium.

Keywords: R&D network, innovation policy, intermediaries, TERGM

1. Introduction

European innovation policy is increasingly characterised by a complex, multi-level architecture, where instruments such as the European Union's Framework Programmes (EU FPs) and Cohesion Policy funds (primarily the European Regional Development Fund - ERDF) coexist and operate under distinct rationales. The FPs adopt a spatially blind approach, prioritising scientific excellence and global industrial competitiveness with little concern for territorial inclusivity. In contrast, Cohesion Policy is place-based, and through the ERDF it addresses regional disparities and directly supports projects of local economic and social significance (Corpakis, 2020). A central policy question concerns the extent to which these programmes can work in synergy as a way of optimising resource allocation, strengthening efficiency and achieving greater innovation impact than would be feasible through individual interventions alone (European Court of Auditors, 2022; Perez et al., 2014).

Existing studies and policy documents have largely examined this question from a top-down perspective, focusing on regulatory or thematic alignment, and institutional coordination between programmes' managing authorities (European Court of Auditors, 2022; Doussineau & Bachtrögler-Unger, 2021; Cappellano et al., 2024). Relatively little research has concentrated on analysing how economic actors interact and respond to policies of different spatial scale. Yet, realising synergies between EU-level and regional innovation policies requires more than priority alignment or policy coordination. It also depends on the relational behaviour of beneficiaries and the network structures in which they are embedded. In particular, the formation of collaborative ties across policy levels can be seen as an important structural precondition for cross-fertilisation, knowledge spillovers and resource complementarities.

Empirical research has shown that knowledge is not a universally accessible resource that flows freely among spatially co-located organisations. In other words, EU-level excellence research does not trickle down by default, nor do regional discoveries scale up spontaneously. Instead, knowledge diffuses selectively through network connections between specific actors (Fitjar & Rodríguez-Pose, 2017; Giuliani & Bell, 2005). Moreover, intermediary organisations may play a crucial role by brokering otherwise improbable links across spatial and institutional divides (Howells, 2006; Caloffi et al., 2023). Overlooking the complexity and the multi-layered nature of these network connections limits our ability to identify the structural conditions under which knowledge synergies – and by extension, more cohesive innovation systems – can emerge across the EU. To our knowledge the question of how actors embedded in different innovation policy frameworks interact has received little attention in the literature so far (Bachtrögler-Unger & Doussineau, 2020). No prior study has directly examined how embeddedness in the European network of research and development (R&D) shapes companies' propensity to form collaborative partnerships within their local R&D networks.

On the one hand, prior work suggests that organisations successfully competing for EU excellence funding possess a priori advanced knowledge capacities, strong international orientation, and above average absorptive capacity (Barajas & Huergo, 2010; Dekker & Kleinknecht, 2008). Following participation, they are likely to accrue further enhancements of technological capabilities and labour productivity (Aguiar & Gagnepain, 2017; Kátay et al., 2018). At the same time, the literature on innovation clusters highlights how successful, internationally oriented companies may begin to act as "external stars", avoiding interaction with local less knowledgeable firms (Giuliani, 2011; Morrison, 2008). It remains unclear whether embeddedness in the highly competitive European research landscape is similarly associated with disengagement from localised collaborative networks.

Scholars have further discussed the role of innovation intermediaries in orchestrating otherwise "unlikely" partnerships between distinct organisations in regional networks. Particular attention has been given to public research organisations (PROs) – universities and research centres – which due to their size, broad research portfolios and knowledge-dissemination orientation, tend to occupy central positions in regional knowledge networks and perform a range of mediation services (Françoso & Vonortas, 2023; Janssen et al., 2020; Janssen & Abbasiharofteh, 2022; Kauffeld-Monz & Fritsch, 2013). As mentioned by Caloffi et al. (2015) though, we are lacking context-specific evidence on how intermediaries operate, including whether PROs may be in a position to foster ties between FP beneficiaries and local actors in regional networks.

Hence, to enrich both the literature on knowledge dissemination across policy-induced networks of different spatial scale and the discussion on innovation intermediaries, in this paper we trace the collaborative behaviour of FP beneficiaries in the context of their domestic R&D networks. We explore how participation in excellence-driven European research networks affects their regional engagement and we further assess the potential mediating function of PROs in this process. The analysis holds value for understanding the role of FP beneficiaries as conduits of externally sourced knowledge. On the one hand, it can shed light on whether embeddedness in international excellence projects facilitates or hinders intra-regional tie formation in local R&D network. On the other hand, by disentangling the contribution of PROs as innovation intermediaries, we can provide guidelines on better orchestrating strategic connections between FP beneficiaries and local stakeholders. This can help translate the knowledge gained from excellence-driven research into tangible regional innovation, which is a key step toward accelerating the development of synergies between Europe's major innovation policy domains.

To address our questions empirically, we examine the collaborative patterns of local firms in the Spanish region of Valencia between 2016 and 2022 in response to annual R&D calls, launched by the regional government and financed through the ERDF. Our methodology involves retrieving, cleaning and integrating data from three distinct sources: public records of both *funded* and *unfunded* R&D partnerships from the websites of the Valencian Institute for Business Competitiveness and the Valencian Innovation Agency; CORDIS records on Valencian firms' participation in the Seventh and Eight FPs, as well as the Competitiveness and Innovation FP; and firm-level data from the Iberian Balance Sheet Analysis System. The inclusion of both funded and unfunded partnerships on the regional level allows us to observe genuine partner selection patterns of local actors, independent of funding agencies' selection bias. Based on the comprehensive data collection we can investigate how companies form regional ties conditioned on their experience in FP-funded excellence project, and their connection to PROs, while simultaneously controlling for a range of firm-specific characteristics which are known to influence partnership formation, including age and size among others (Roijakkers & Hagedoorn, 2006).

Given the relational and longitudinal nature of our data, we employ a set of Temporal Exponential Random Graph Models (TERGMs) to model the formation of collaborative ties in a bipartite-affiliation network of firms and projects. As one of the most advanced and theoretically robust social network models, TERGMs offer a key methodological advantage over standard regression techniques. They enable researchers to analyse the mechanisms underlying network formation while accounting for the endogenous dependencies of social networks – specifically how the presence of existing ties influences the emergence of new ones (Harris, 2014). Moreover, we are interested in tracing the collaborative patterns of regional organisations, conditioned on their embeddedness in FP networks. By simulating how actors connected to

multiple policy-induced networks interact over time, TERGMs can offer novel insights on the diffusion of knowledge within and between different spatial scales.

Our results indicate that participation across international FP and domestic R&D schemes is neither fully substitutive nor fully complementary. While few of the Valencian companies we study engaged in both types of collaborative networks, such firms appear particularly proactive when it comes to forming regional partnerships. Moreover, our results show that PROs play a crucial role in facilitating regional partnerships for FP beneficiaries, acting as important innovation intermediaries that bridge policy frameworks of different spatial scale. Still, we find that FP beneficiaries show preference for other FP beneficiaries when they search for partners in regional schemes.

The rest of the paper is structured as follows. Section 2 develops the conceptual background leading up to the main research questions. Section 3 explains our data sources and research methodology. Section 4 presents and discusses the findings, while Section 5 concludes the paper with a discussion of the broader implications of our research for the discipline and provides practical recommendations for policy.

2. Theoretical framework

European support for research and innovation is channelled through two central mechanisms, which differ substantially in their funding principles and procedures. The Framework Programmes are centrally managed by the European Commission and guided by a logic of scientific and technological excellence, with highly competitive calls issued at the EU level. In contrast, the ERDF operates under a cohesion-oriented logic, aiming to reduce regional disparities through place-based innovation efforts. Its management is shared between the Commission and Member States through calls for projects at national and regional level (European Court of Auditors, 2022; Molica & Marques Santos, 2024).

The concept of building synergies between FPs and ERDF gained significant traction during the 2014-2020 programming period (Doussineau & Bachtrögler-Unger, 2021). The overarching rationale was to optimise the allocation of resources, build critical mass in priority areas, and generate greater innovation impact than would be possible through siloed interventions (Doussineau & Bachtrögler-Unger, 2021). In the language of the European Council (2020, p.18) synergies pursue “sharing excellence” and “enhancing regional R&I capacity and the ability of all regions to develop clusters of excellence”.

The notion of “sharing excellence” presumes that knowledge generated in one part of the system can be effectively translated, diffused and absorbed in others. Yet, research on knowledge transfer shows that this process is shaped by structural and relational conditions between actors. For instance, successful knowledge exchange often depends on various forms of proximity between organisations – such as cognitive, organisational, or social proximity – as well as differences in perceived status, the nature of actors’ knowledge bases, or access to non-local networks among other factors (Boschma, 2005; Nooteboom et al., 2007; Giuliani, 2005; Fitjar & Rodríguez-Pose, 2011). Additionally, scholars have emphasised the critical role of intermediaries or “knowledge gatekeepers” in stimulating otherwise unlikely links between various economic actors (Howells, 2006; Caloffi et al., 2023).

When it comes to building synergies, most studies and policy reports have approached the issue of "sharing excellence" from a top-down perspective, looking at thematic or regulatory coordination at the level of policy design and governance. For example, key concerns include whether the FPs and Cohesion Policy instruments feature alignment in priorities or whether managing authorities at regional, national and international level engage in effective vertical and horizontal coordination (European Court of Auditors, 2022; Perez et al., 2014).

However, focusing solely on policy design and governance risks overlooking the structural and behavioural conditions needed for synergies to materialise in practice. Complementarities and project cross-fertilisation are not automatic outcomes of regulatory alignment; they depend, also, on the formation of links between actors embedded in distinct policy frameworks (Uyarra & Flanagan, 2010). A 2020 study of ERDF and Horizon 2020 beneficiaries adopted such a micro-level perspective, and found that around 15% of R&I projects co-funded by the ERDF are carried out by beneficiaries that also receive Horizon 2020 funds (Bachtrögler-Unger & Doussineau, 2020). This overlap measure is only a first step towards understanding the actual interaction across programmes. For instance, dual funding does not guarantee that organisations integrate knowledge or forge structural links that connect local and international R&D efforts. What matters is also whether FP beneficiaries build ties with domestic actors. The aim of this paper is to enrich this emerging line of research and highlight the structural conditions under which synergies can emerge by analysing (1) the collaborative behaviour of FP beneficiaries in regional knowledge networks and (2) the intermediary role played by public research organisations (PROs).

2.1. The effect of EU FP involvement for companies' tie formation in regional R&D networks

In this section we unpack how FP involvement may influence firms' position and behaviour within regional R&D networks. Participation in EU FPs brings about multiple benefits for companies, but it is also a strong signal of their pre-existing capabilities. First, since the FPs are notoriously competitive and prioritise excellence in science (Corpakis, 2020), organisations which have successfully competed for such type of funding are likely to possess *a priori* advanced knowledge capabilities and belong to what Dekker and Kleinknecht (2008) call the "elite" of innovating firms in Europe. Already at the application stage, companies which submit proposals appear to have above-average absorptive capacity and strong international and export orientation (Barajas & Huergo, 2010). They are also better prepared to handle the administrative burden and the initial sunk costs of managing an R&D project (Enger & Castellacci, 2016). Next, the actual collaboration through EU FP funding also brings about benefits, even after controlling for the self-selection bias of "elite" firms. Because of the intrinsically pre-competitive[1] nature of framework programmes, these benefits are more closely associated with intangible assets, such as enhancement of technological capabilities, expansion of research lines and skill development (Luukkonen, 2000). Thus, for example, Dekker & Kleinknecht (2008) found no correlation between FP participation and increased innovative sales, whereas Aguiar & Gagnepain (2017) and Kátay et al. (2018) highlight substantial *long-term* effects on the post funding labour productivity of FP beneficiaries. Moreover, Barajas et al. (2012) demonstrate that such effects are likely driven by improvement in innovative technological capabilities. Participation in FPs also enhances a firm's integration within European R&D networks and contributes to greater internationalisation, since projects are by default geographically diverse and require a minimum number of partners from different countries.

[1] Pre-competitive research refers to R&D for which commercial possibilities remain five to ten years in the future.

Because of the benefits associated with FP participation, companies' embeddedness in an international network of excellence may condition them to behave differently when it comes to regional collaboration. For instance, prior studies on industrial clusters have documented the propensity of leading, more successful firms, which are among the most externally oriented and technologically advanced, to act as "external stars", that is to avoid interaction with local less knowledgeable firms (Giuliani, 2011; Morrison, 2008). The mere geographical proximity and co-location of companies within the same region, and sometimes within the same cluster, may facilitate business information flow, but knowledge sharing remains selective and often limited to a "hub" of organisations with similarly strong knowledge bases (Giuliani, 2005). In that sense, leading companies are more prone to circulate the knowledge gained among other "external stars", who have comparable capabilities, thus giving rise to a sort of exclusive club of firms. Connections to isolated firms, however, rarely occur (Giuliani, 2005).

At the same time, the involvement of certain firms in international collaborations can elevate their status compared to local firms that lack such long-distance connections. Consequently, these "external stars" may attract a higher share of local firms seeking collaboration. This phenomenon reflects the status effect, or preferential attachment, where specific actors within a network become more attractive than others (Barabási & Albert, 1999), as they are perceived to be a source of greater knowledge and experience. Empirical studies provide limited evidence that preferential attachment is a primary driver of tie formation in collaboration networks (Balland et al., 2016; De Stefano & Zaccarin, 2013). However, some research suggests that the status effect may influence the formation of new ties, particularly in high-uncertainty contexts (Lazega et al., 2012), such as the early stages of industrial cluster development (Abbasiharofteh, 2020; Ter Wal & Boschma, 2011). Considering that R&D activity is inherently risky and that applying for public funds requires administrative experience, FP beneficiaries' advanced knowledge base and accumulated expertise in securing competitive funding can be particularly attractive within a regional context. It is thus plausible that external stars attract significant future intra-regional collaborative ties. Based on these two lines of argument, we pose the following research question:

Q1: How does participation in EU FPs influence companies' propensity to form ties in regional R&D networks?

2.2. The role of public research organisations (PROs) as innovation intermediaries

Next, we argue that the propensity for regional tie formation of FP beneficiaries may be facilitated by regional innovation intermediaries. The literature on innovation intermediaries has expanded significantly over the last 20 years since the seminal work of Howells (2006) and the number of distinct definitions (e.g., brokers, gatekeepers, boundary spanners) and categorisations has proliferated (for a systematic overview see for instance Caloffi et al. (2023); Colovic et al. (2024); Kivimaa et al. (2019)). Among the many heterogeneous services intermediaries provide is the brokering of "unlikely" relationships that may not otherwise occur on their own. In this section we focus on the potential of public research organisations to perform this role of bridging EU FP beneficiaries and regional actors.

Prior studies have demonstrated that PROs tend to occupy central positions in regional knowledge networks, as a result of several factors (Françoso & Vonortas, 2023; Kauffeld-Monz & Fritsch, 2013). First, compared to SMEs and even large companies, PROs possess greater size and resources to maintain multiple R&D connections at a time. Second, they tend to have expertise across a broad spectrum of knowledge domains, which contributes to a larger research

portfolio and increases their absorptive capacity as well as their ability to engage in a diversity of knowledge interactions (Françoso & Vonortas, 2023; Graf, 2011). Third, unlike private companies, PROs operate under an open science paradigm, which means that they have both the incentive structure and the willingness to initiate knowledge transfer activities. This approach has been formalised as the "third mission" of universities (Crespo & Vicente, 2016).

However, it remains unclear whether the mediating role of PROs extends to forming bridging ties between internationally embedded FP beneficiaries and local actors within the region. For example, Janssen & Abbasiharofteh (2022) found that, contrary to the goals of mission-oriented partnerships (e.g., in health and energy), collaborations in the Netherlands tend to occur among similar firms, potentially limiting knowledge diversity. This shortfall may stem from network failures in aligning problem and solution spaces (Wanzenböck et al., 2020). In other words, intermediaries may focus on increasing network density rather than fostering the formation of 'missing links' (Suire & Vicente, 2009). Hence, we pose the following question:

Q2. Does engagement with PROs facilitate FP beneficiaries' propensity to form ties in regional R&D networks?

3. Data & methodology

3.1. Empirical context and data curation

To address the research questions empirically we focus on Valencia region in Spain and draw on *three* distinct datasets. The first one features information on regional R&D partnerships between Valencian organisations, which applied for government funding under the Smart Specialisation framework in the period 2016-2022. Since Smart Specialisation is part of European Cohesion Policy, all regional partnerships we consider were funded either partially or entirely through the ERDF. The second dataset includes information on Valencian organisations' involvement in the Seventh and Eight Framework Programmes (FP7 and Horizon 2020), and the Competitiveness and Innovation Framework Programme (CIP), and the third one offers financial information on individual companies in Spain. The combination of these data offers a unique opportunity to examine beneficiaries of two different policy frameworks, and to assess how participation in FP-funded excellence projects conditions companies' collaborative behaviour in the regional knowledge network.

First, to gather information on regional partnerships, we relied on public records published on the websites of two of Valencia's leading public funding organisations: the Valencian Institute for Business Competitiveness (IVACE) and the Valencian Innovation Agency (AVI)[2]. Together AVI and IVACE manage approximately 75% of all public funding designated for the implementation of the regional Smart Specialisation Strategy – RIS3CV (Generalitat-Valenciana, 2019). Hence, by employing data from these two agencies, we can be fairly confident that we are indeed capturing a substantial proportion of ERDF-supported R&D activity in the region.

Since we are interested in analysing firms' propensity for tie formation, we collected and systematised data from three *collaborative* regional funding calls which open on an annual basis:

[2] IVACE was established in 1984, and its mission is geared toward assisting Valencian SMEs in increasing their competitiveness and overall innovative capacity. AVI was created more recently in 2018, specifically for the purpose of managing the innovation strategy of Valencia and improving the regional productive model. Under RIS3CV, the two entities operate in parallel to promote the generation, exchange, and exploitation of new knowledge in the Valencian region.

R&D in cooperation (managed by IVACE), *Strategic projects in cooperation* and *Consolidation of the business value chain* (both managed by AVI)[3]. Although the calls handled by each agency have certain differences in eligibility criteria, they all aim to support downstream R&D projects which deal with either *industrial research and design*, or *experimental development*. An important distinction between the three funding streams is that R&D in cooperation (managed by IVACE) is only open to private companies, with mandatory participation from at least one SME, while the two calls managed by AVI are open to all types of organisations (firms, universities, research centres, etc.). Thus, we are *de facto* capturing a range of partnership formations that include firms of different sizes and in some instances feature a PRO partner.

One of the most notable advantages of our data is that it includes both the *funded* and *unfunded* regional partnerships. This allows us to trace the collaborative behaviour of regional organisations irrespective of the funding and selection bias of the grant agencies, in this case AVI and IVACE.

Next, in order to identify the FP beneficiaries, we extracted information for all organisations active in the regional partnership network and recorded their participation in European excellence projects by matching their id to the CORDIS database. We considered projects funded under FP7, Horizon 2020 and CIP, spanning a period of 8 years: from 2008 to 2015. These programmes prioritise funding for exceptionally promising and highly innovative projects. Given the extensive participant network, broad geographic coverage, and substantial budget associated with EU FP projects, these initiatives offer significant opportunities for internationalisation and integration into top-tier European research and innovation consortia.

Finally, we complemented our information for all companies active in regional partnership by using the SABI (Iberian Balance Sheet Analysis System) database, which contains financial details on more than 2.6 million registered firms in Spain and Portugal. By matching unique Spanish tax identifier numbers (CIF), we retrieved information on 100% of the private for-profits in our sample, specifically their age, size (both by employee count and by annual turnover), registered address, and economic activity.

3.2. Data overview

Our starting sample includes 444 regional R&D partnerships and 554 unique Valencian organisations, covering a seven-year observation period from 2016 to 2022. Given that private companies comprise 90% of those organisations, and that we were able to collect detailed information on their individual characteristics, we focus our attention on the collaborative choices they make. We exclude a limited number of other organisational types, such as cooperatives, associations, and non-profits, which altogether account for less than 4% of the starting sample. We retain information on firms' links to PROs. The latter account for the remaining 6% of organisations in the original sample. Since our primary interest lies in the *collaborative* relationship between private companies, we also exclude R&D partnerships which include only one firm (approximately 26% of the starting 444 regional alliances). Figure 1 shows the spatial distribution of all firms in the original sample before removing isolates. We note that most of them are located around the three main economic centres of the region, namely Valencia, Alicante and Castellón. Figure 1 further illustrates how we convert our data on firms and partnerships into a network projection for visualisation purposes. Following the filtering of

[3] Further information on the respective calls is available on the official websites of the two agencies: AVI (https://innoavi.es/en/) and IVACE (https://www.ivace.es/index.php/es/).

both partnerships and organisations, the final working sample consists of 447 firms and 314 collaborative partnerships.

To identify the FP beneficiaries from those 447 firms, we rely on the second dataset on EU FP participation. We estimate that roughly 15% of the 447 firms (n = 68 firms) had been involved in at least one FP project in the 8 years prior to the start of our observation window in 2016. Notably, these 68 firms represent one fifth (21%) of all Valencian companies with EU FP exposure in those 8 years. Figure 2 illustrates the breakdown of Valencian firms' participation in the two policy frameworks.

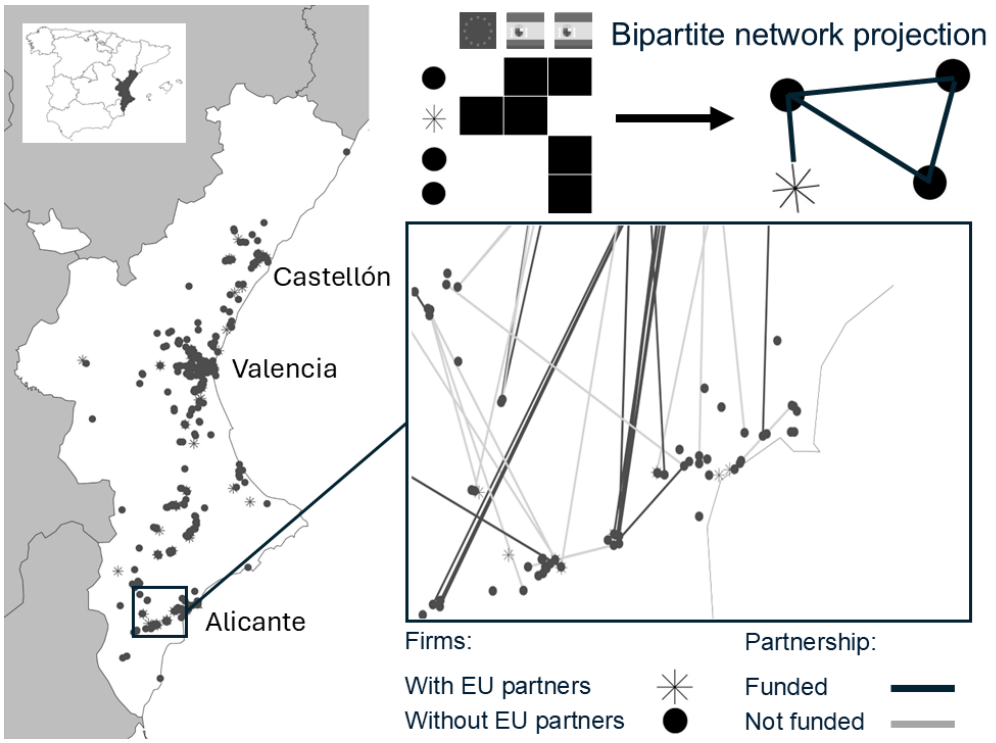

Figure 1. Collaborative network formed by firms' involvement in local R&D partnerships and their spatial distribution across the Valencian region.

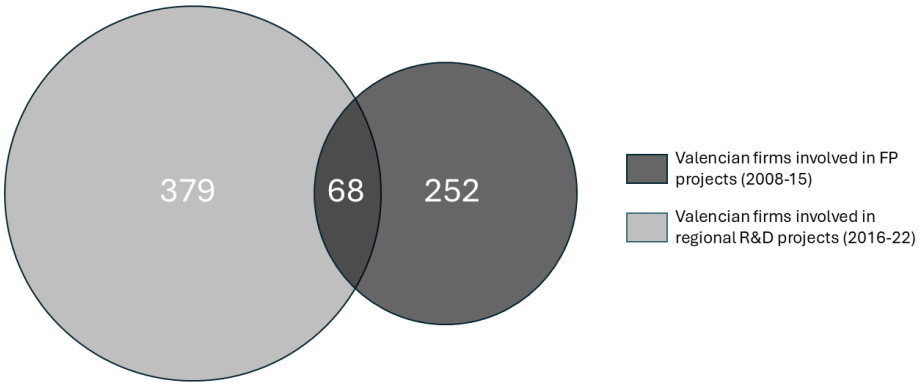

Figure 2. Involvement of Valencian firms in collaborative R&D partnerships of regional and European scale.

We split our working sample in two non-overlapping periods: t1 (2016-2020) and t2 (2021-2022), which allows us to model the forces behind tie formation between t1 and t2. The division was made to ensure a relatively even distribution of partnerships across both periods. Notably, funding availability and the popularity of the regional programmes increased over time, which explains why the latter two years (t2) attract almost the same number of applications as the preceding five (t1).

3.3. Estimation strategy

A critical aspect of our analysis involves accounting for the interdependencies among firms in forming collaborative relationships. Generalised linear models, however, overlook these interdependencies due to their assumption of independence. To address this limitation, Exponential Random Graph Models (ERGMs, also known as p* models) incorporate endogenous effects in modelling (Harris, 2014). Network endogenous effects are dependencies within a network that influence relationships, such as *transitivity* (where friends of friends are likely to connect), *homophily* (where similar nodes connect), and *preferential attachment* (where nodes with more connections tend to form additional ties) (Robins et al., 2009). To this end, ERGMs employ Markov dependence to infer that a link between nodes A and B is conditionally dependent on other links involving A and B, moving beyond the assumption of dyad independence (Robins et al., 2007). In economic geography, innovation and regional studies, ERGMs are widely used to model knowledge transfer between actors, taking into consideration endogenous network effects (Abbasiharofteh & Broekel, 2020; Broekel & Bednarz, 2018; Capone & Lazzeretti, 2018; De Stefano & Zaccarin, 2013; Kabirigi et al., 2022; Xavier Molina-Morales et al., 2015; Zinilli et al., 2024).

Following Harris (2014), the general form of ERGMs is:

$$\mathrm{P}\,(\mathrm{Y}=\mathrm{y}) = (\frac{1}{c})exp\left\{\sum_{k=1}^{k}\theta_k z_k(y)\right\} \quad (1)$$

where $\frac{1}{c}$ is a normalising term ensuring the result is a probability between zero and one and all probabilities for all possible networks sum up to one. Network statistics included in the model (e.g., homophily) are represented as z_k with corresponding coefficients θ_k. The dependent variable is the network's tie structure, modelling the likelihood of connections being formed.

An extension of ERGMs allows for modelling panel network data. Specifically, Temporal ERGMs (TERGMs) can capture network evolution across multiple time windows by modelling tie formation and dissolution (Krivitsky & Goodreau, 2017). In this study, we focus solely on tie formation, as we investigate R&D networks in which collaborative ties naturally dissolve depending on funding availability and project duration.

It is important to understand the distinct nature of bipartite networks (e.g., R&D collaboration networks) and the approach to modelling them with TERGMs. A bipartite network consists of two distinct sets of nodes, where connections (edges) are only formed between nodes from different sets, not within the same set. Researchers may create a unipartite network through a bipartite network projection (see Figure 1) and apply TERGMs. However, such projections involve assumptions and may result in a loss of collaboration-specific information (Abbasiharofteh et al., 2023). Following the work of Broekel & Bednarz (2018) we estimate bipartite networks without network projection, incorporating network statistics for both sets of nodes (i.e., b1: firms and b2: R&D partnerships).

The first structural-level variable, *edges,* controls for the baseline probability of forming ties within the network, reflecting the overall tendency for connections to exist. The terms *gwb1deg* and *gwb2deg* represent two model statistics that control for effects related to the degree distribution of firms and project partnerships. The inclusion of these statistics is motivated by the Matthew effect, also known as the "rich-get-richer" effect (Barabási & Albert, 1999).

The term *gwb1dsp* adds a network statistic to the model, capturing the geometrically weighted distribution of dyadwise shared partners for dyads in the first bipartition (firms) of the collaboration network. This term serves as the bipartite equivalent of the geometrically weighted dyadwise shared partner statistic. Scholars describe this effect as multi-connectivity, where a network evolves to include multiple direct and indirect links between diverse nodes (Abbasiharofteh, 2020; Powell et al., 2005).

Moreover, to investigate the attribute-based homophily effect, we also include *b1nodematch* (i.e., dyadic attribute), which adds a network statistic based on whether or not firms have at least one international collaborative partner. Finally, we include an exogenous variable, *b2Deg3*, which adds a statistic accounting for the number of b2 nodes (projects) with at least three connections to b1 nodes (Broekel & Bednarz, 2018). This variable is *de facto* controlling for the size of projects that include more than three firm partners.

3.4. Variable construction

Beside the network-level variables described above, we operationalise the main concepts in our analysis using binary variables, which allow for more efficient estimation and convergence of the TERGM. We create a list of variables either on the firm or on the project partnership level, as described in Table 1.

Our primary variable of interest is the embeddedness of Valencian firms in the competitive landscape of European excellence research and innovation. To capture this condition, we introduce a binary node-level variable called FP_participant which takes the value of 1 if the focal firm has participated in at least one EU FP project in the eight years preceding the period of observation. The threshold of one project is dictated by extensive longitudinal studies on the dynamics of FP networks, which demonstrate the presence of structural inertia (Balland et al., 2019). As established organisations begin to progressively dominate the network, it becomes evident that the barriers to first-time entry are higher than those for subsequent participation. In that sense, securing even one involvement in an FP project is a significant milestone, when compared to firms with no such prior experience.

Since we are also interested in assessing the moderating role of public research organisations in facilitating link formation, we construct a variable PRO which accounts for the presence of a link between the focal firm and a regional PRO. This approach is similar to the one adopted by Janssen & Abbasiharofteh (2022) in their study of boundary-spanning R&D ties in the Dutch innovation system.

We introduce several control variables to the TERGM. First, we account for the size of the focal firm, distinguishing between SMEs and large enterprises, as their approaches to knowledge sourcing and management tend to differ. For SMEs alliances with external partners are often driven by internal resource limitations, including financial constraints and a deficiency in technological or managerial expertise (Garcia-Martinez et al., 2023). This also means they prioritise applied projects that offer immediate, tangible benefits, which are crucial for their

survival and growth (Nepelski et al., 2019). Large firms, on the other hand, may be much more driven by knowledge acquisition incentives, partnership building, or technology watch, rather than immediate market needs (Aguiar & Gagnepain, 2017).

Next, we control for the age of firms, since younger companies are generally expected to have sparser or underdeveloped partnership networks as compared to their more mature well-established counterparts. We also account for the spatial distribution of firms in our sample. Geographical proximity to potential collaborators facilitates opportunities for face-to-face interaction as well as knowledge and information sharing (Boschma, 2005). We construct a node-level variable GeoProx which reflects a firm's geographical proximity to other potential collaborators from the sample, using a 1km radius as a threshold. We also include firms' experience in applying for the regional R&D calls during the first period of observation t1. On the project level, we introduce a variable Funded, which indicates if the partnership between firms was successful in securing government funding in the local R&D calls.

Among the Valencian firms seeking R&D partnerships through regional policy schemes, only 15% had successful international experience in the context of EU FP projects. This indicates that most companies competing for regional funds lack exposure to the European research and innovation landscape. In addition, just 15% of firms in our sample had established a partnership link with a PRO during the first period of observation. Overall, the regional R&D network features predominantly SMEs (86%) and mature companies with five or more years of experience (74%). 78% of firms have at least one potential collaborator in close vicinity (1 km or less), which is consistent with the map in Figure 1. In the next section we present the results of the TERGM.

Table 1. Description of firm-based and partnership-based variables used in the TERGM.

Variable	Level	Description	N	Share 1 values
FP_participant	*node*	Takes the value of 1 if the firm has participated in at least 1 competitive EU FP project in the 8 years prior to the start of the observation period.	447	15%
PRO	*node*	Takes the value of 1 if the firm has at least one regional link to a PRO during the first period of observation, 0 otherwise.	447	15%
SME	*node*	Takes the value of 1 if the firm is classified as a micro, small or medium-sized enterprise based on turnover[4].	447	86%
Mature	*node*	Takes the value of 1 if the firm was established at least five years prior to the start of the observation period.[5]	447	74%
Exp	*node*	This variable reflects a firm's experience and assumes the value of 1 if the firm has had at least one other project application in the first period (t1) of the observation window.	447	15%
GeoProx	*node*	This variable is set to 1 if the focal firm has at least one other firm from the sample located within a 1 km radius; else it is set to 0.	447	78%
Funded	*partnership*	Takes the value of 1 if the project has received funding from a regional funding agency, 0 otherwise.	314	70%

4. Results and Discussion

We estimated five Temporal Exponential Random Graph Models (TERGMs), as summarised in Table 2. Each model includes the Akaike Information Criterion (AIC) value, a metric used to assess the relative quality of statistical models, with lower AIC values indicating better model fit. Model 3 demonstrates the best fit, though the differences in AIC values across models are marginal. Additionally, one can compare the attributes of networks simulated by the TERGMs to those of the observed network. Appendix A provides visual representations of model fit (Krivitsky & Goodreau, 2017). Similar to the AIC values, the differences in visual goodness of fit across models are minimal.

We first report the results of our baseline model. The estimated coefficients in Model 1 indicate that older companies – those that were at least 5 years in business at the start of our observation period – are generally less collaborative when compared to younger enterprises. In line with prior studies (Heringa et al., 2016; Ponds et al., 2007), spatial proximity to potential collaborators and the possibility of face-to-face interactions contributes to firm's propensity to form R&D

[4] Based on EU recommendation 2003/361: - Micro enterprises: ≤ € 2 m turnover, - Small enterprises: € 2 -10 m turnover, - Medium-sized enterprises: € 10 - 50 m turnover, and - Large enterprises: ≥ € 50 m turnover.

[5] We follow OECD classifications, which define young firms as those under 6 years old (OECD, 2021).

partnerships. Moreover, prior experience in applying for regional calls appears positively associated with future applications, although having participated in a *funded* project matters even more. As for firm size, we observe that small and medium-sized enterprises are generally more reluctant to join collaborative R&D partnerships in comparison with larger companies. Even though large companies make up a smaller portion of all network participants, they seem to be more active in forming partnerships. This is consistent with earlier studies (Janssen & Abbasiharofteh, 2022), and may be associated with SMEs' inherent resource constraints. The coefficients of the control variables align with our expectations, providing confidence in the robustness of the model. The structure-level variables are all significant and consistent with earlier empirical works. For instance, a negative and significant edges coefficient is common and generally indicates a lower likelihood of tie (edge) formation than would be expected in a random network with the same density (for a review of empirical works see Hermans (2021)). We refrain from interpreting each structure-level variable, as doing so does not directly contribute to answering our research question. These variables are included solely to ensure the robustness of our results.

Table 2. Summary of results obtained from the five TERGM estimations.

	Model 1	Model 2	Model 3	Model 4	Model 5
edges	-5.56 (0.95) ***	-5.70 (0.95) ***	-6.19 (0.98) ***	-5.70 (0.99) ***	-6.25 (1.01) ***
gwb1deg	5.79 (0.71) ***	5.89 (0.71) ***	6.00 (0.74) ***	5.87 (0.72) ***	5.80 (0.73) ***
gwb2deg	11.17 (3.49) **	11.66 (3.41) ***	12.33 (3.53) ***	12.00 (3.57) ***	12.95 (3.57) ***
gwb1dsp	-3.42 (0.23) ***	-3.35 (0.22) ***	-3.22 (0.24) ***	-3.26 (0.26) ***	-3.42 (0.23) ***
b2Deg3	3.88 (0.49) ***	3.89 (0.49) ***	3.87 (0.49) ***	3.81 (0.51) ***	3.90 (0.49) ***
FP_participant		0.69 (0.18) ***			
PRO			0.68 (0.17) ***		
FP_participant+PRO				1.20 (0.21) ***	
homophilyFP_participant					0.34 (0.14) *
SME	-0.91 (0.18) ***	-0.91 (0.18) ***	-0.86 (0.18) ***	-0.97 (0.18) ***	-0.90 (0.18) ***
Mature	-0.63 (0.17) ***	-0.78 (0.17) ***	-0.61 (0.17) ***	-0.72 (0.17) ***	-0.58 (0.17) ***
Exp	0.80 (0.17) ***	0.78 (0.17) ***	0.54 (0.19) **	0.54 (0.19) **	0.79 (0.17) ***
GeoProx	0.95 (0.26) ***	0.88 (0.27) **	0.93 (0.26) ***	0.84 (0.27) **	0.96 (0.27) ***
Funded	1.86 (0.41) ***	1.86 (0.41) ***	1.87 (0.41) ***	1.86 (0.43) ***	1.82 (0.42) ***
Log Likelihood	-2296.08	-2289.13	-2287.39	-2282.17	-2293.96
AIC	4612.15	4600.26	4596.78	4586.33	4609.92
BIC	4710.67	4708.63	4705.16	4694.70	4718.29

*** p < 0.001; ** p < 0.01; * p < 0.05

Next, we move on to assessing the effect of our main variable of interest: firms' participation in the European network of research and innovation. The results from Model 2 suggest that participation in EU FP projects is positively associated with regional tie formation. Exponentiating the positive coefficient (0.69), we calculate that Valencian firms which have been a member of a competitive European project are almost twice as likely to join a regional partnership and apply for regional funds than other local firms that lack such experience. Model 3 further shows that having a connection to a PRO – our moderating factor – exhibits a positive association with regional tie formation. Moreover, when we consider the combination of FP_participant and PRO in Model 4, we notice that FP beneficiaries that are linked with PROs are even more likely (3.2 times) to form collaborative ties. In sum, while FP participation and PRO links individually show positive association with regional tie formation, their combination produces a notably stronger effect.

Finally, Model 5 includes a homophily variable based on the FP_participant dyadic attribute. It reveals that although FP beneficiaries are active participants in the regional knowledge network,

they tend to show preference for partners of similar status, that is other FP beneficiary firms. The coefficient of the homophily variable based on the FP_participant attribute is positive and significant at the 5%. This pattern resembles a "rich-get-richer" effect, where already internationally linked firms continue to attract more collaborations with other internationally linked firms in the region, potentially reinforcing existing inequalities in access directly to local and indirectly to international knowledge networks.

We proceed by discussing the key takeaway from our analysis. On the one hand, our preliminary exploration of the data showed that at the start of the observation period only 15% of Valencian companies participating in regional R&D calls had some experience with EU FP projects. It appears that the two types of European innovation schemes – those targeting excellence and industrial competitiveness in a spatially blind approach and those prioritising place-based solutions – are not only tackling diverse sets of challenges, but they also cater to different stakeholder groups. In other words, similar to Bachtrögler-Unger & Doussineau (2020) we see limited overlap between the firms engaged in regional initiatives and those involved in European-level partnerships. This is not entirely surprising and perhaps desirable from a policy standpoint, since firms which cannot compete for highly competitive FP grants, still have the opportunity to receive support through ERDF funds earmarked for regional R&D. One concerning implication of this observation, however, is that the structural potential for knowledge spillovers and knowledge integration between the two types of schemes – whether through upstream or downstream synergies – remains rather limited.

On the other hand, when looking at the dynamics of the regional R&D network, we discover that FP beneficiaries who do engage domestically are particularly pro-active in their tie formation. Compared to other regional firms which lack such international experience, FP participants are twice as likely to forge regional partnerships and seek regional funding. However, as the results of Model 5 confirm, these partnerships tend to involve other externally oriented FP beneficiary firms. This finding offers a slightly more complex interpretation to earlier studies which showcase how external orientation may contribute to disengagement with the local context – a behaviour previously observed in industrial clusters with so-called "external star" companies (Giuliani, 2011; Morrison, 2008). Our analysis paints a nuanced picture: while little structural overlap exists between the firms engaged in different policy schemes, those FP beneficiaries who remain locally active are becoming dominant players in the regional ERDF-funded R&D network. Rather than being passive one-time participants, such firms initiate frequent partnerships, but they still show preference for other competitive internationally embedded firms. This pattern creates a rather constrained environment for knowledge spillovers and genuine policy synergies to take root.

Furthermore, the results of the TERGMs suggest that FP beneficiaries with a link to PROs are even more likely to form regional partnerships. This indicates that PRO connections are crucial for leveraging the experience of internationally embedded actors in the case of domestic R&D networks. It is likely that the central position of PROs in local innovation ecosystems facilitates FP beneficiaries' ability to establish local partnerships. In other words, they benefit from both international exposure and from access to local research infrastructure which gives them a unique advantage. These findings are consistent with research by Janssen & Abbasiharofteh (2022) who also report that tie formation between two organisations increases when both have a connection to a PRO, although they find an opposing effect when only one of the organisations has such a link.

From a broader perspective, our results imply that PROs' function as innovation intermediaries is not limited to bridging geographically distant actors or directly diffusing distant non-redundant knowledge in the local ecosystem (Françoso & Vonortas, 2023; Graf, 2011; Kauffeld-Monz & Fritsch, 2013). When examining the Valencian regional R&D network, we observe that PROs are also associated with *strengthening* partnerships between firms which operate in different innovation policy frameworks. Thus, our research responds to recent calls for context-specific empirical evidence on the range of services intermediaries provide (Caloffi et al., 2015).

Multiple policy suggestions emerge from this analysis. As a first step, the Valencian government could consider providing institutional support to boost the currently low share of EU FP beneficiaries engaging in local R&D calls. Beyond creating opportunities for synergies, such measures can also ensure better alignment between international research outcomes and local innovation goals, as defined by the Valencian Smart Specialisation Strategy. On a broader scale, policymakers' emphasis may need to shift from simply increasing the overall R&D network density to prioritising targeted interventions that strengthen critical links between stakeholders from different policy frameworks. A concrete recommendation concerns the role of PROs as innovation intermediaries. For example, fostering stronger links between FP beneficiaries and PROs has the potential to enhance the integration of advanced externally oriented firms into regional R&D initiatives, thereby improving knowledge exchange and collaboration, in a "*rising tide lifts all boats*" scenario.

5. Conclusion

This paper seeks to contribute to the ongoing scholarly and policy debate on how Europe's major innovation policies – the spatially blind Framework Programmes and the place-based Cohesion Policy – can be better aligned to foster synergies (European Court of Auditors, 2022). Adopting inferential network analysis, the study zooms in on the collaborative patterns of Valencian firms participating in both types of policy frameworks. More specifically, it examines how companies' involvement in competitive FP projects conditions their engagement in the context of domestic place-based R&D partnerships, funded under the regional Smart Specialisation Strategy. The study further analyses the role of public research organisations as potential innovation intermediaries that strengthen the engagement of actors from two distinct policy schemes.

Our aggregate results paint a nuanced picture. At first glance, there appears to be little overlap between firms active in both local and international R&D networks. This suggests that FP beneficiaries may not perceive regional calls as a strategic priority. However, a closer look at the behaviour of firms which do engage in both networks reveals that they are domestically active and tend to form partnerships to a greater extent than their regional counterparts who lack such international exposure. This propensity is particularly pronounced when the firm is linked to a PRO. In other words, PROs may have an important role to play when it comes to stimulating critical links and spurring knowledge transfer across actors embedded in different policy frameworks. Yet, we also find evidence that FP beneficiaries show preference for other similarly positioned firms when collaborating in regional R&D calls, which may compromise opportunities for broader knowledge transfer and innovation diffusion across innovation ecosystems.

It should be noted that our study offers an in-depth view of a single region, which limits the generalisability of the findings. The empirical set-up required us to retrieve, disambiguate, and merge three datasets, making the analysis of a larger set of regions beyond the scope of this paper. Another limitation, common to many network studies, is the incomplete visibility of all relationships in which FP beneficiaries may be involved on a local level. However, it is more likely

that this limitation results in an underestimation of the true impact of FP beneficiary firms, and that their importance for regional knowledge networks is possibly greater than our estimations show. A further limitation concerns the possibility of self-selection bias. The observed pro-active behaviour of FP beneficiaries who engage domestically may be partially driven by the intrinsic characteristics of these organisations. As discussed earlier, such firms typically possess advanced knowledge bases and strong absorptive capacity, which enables them to form and sustain multiple partnerships at a time. While our findings document this behaviour, the analysis does not allow us to fully disentangle the underlying causes.

Future research could build on this analysis by examining additional regions and exploring how collaboration dynamics evolve under the influence of both local and EU funding schemes. Although the economic characteristics of Valencia make it comparable to many other regions in south and east Europe, extending the study to other contexts would strengthen the external validity of our findings and allow comparisons across different institutional and policy frameworks. Another important avenue for future investigation concerns the nature of the collaborative projects themselves. In this study we focused on the propensity for FP beneficiaries to form local partnerships, but future research could examine the content of these partnerships and potential evidence of technology transfer or commercialisation. For example, do local R&D projects represent continuation of prior European-level initiatives involving the focal firm, or do they reflect entirely new strategic directions? Studies can also adopt a meso-level perspective and assess whether FP participation by local actors is linked to technological specialisation or enhanced commercialisation capabilities at the level of the region – a research area which has recently benefited from the use of Trademark data (Castaldi et al., 2025). Such insights could add new perspectives on how knowledge is translated and integrated across different knowledge systems and policy frameworks.

The study has important implications for policymakers looking to strengthen synergies between European excellence programmes, such as Horizon Europe, and the Cohesion policy toolbox. Integrating the benefits of the two programmes has been an important priority for the European Commission, particularly in the preparation of the 2021-2027 framework (European Commission, 2022), and forms part of one of the five key flagship initiatives in the New European Innovation Agenda[6]. Greater attention has been given to the possible exploitation of Horizon R&D results using regional funding schemes, and the potential to boost further collaboration between stakeholders from the two programmes. The results of this study demonstrate that knowledge spillover opportunities do exist, as we observe that Valencian FP beneficiaries who engaged in regional calls demonstrated greater pro-activity in tie formation than counterparts who lack such experience. However, not all FP participants pursue local partnerships in the context of domestic R&D calls, and those who do may end up partnering with firms who share their status and international experience. This dynamic implies that regions with fewer internationally engaged firms are faced with limited knowledge spillover potential to begin with, while those regions with a relatively high share of FP beneficiaries cannot expect substantial spillover effects without targeted interventions. To address these concerns, EU-level policymakers could concentrate efforts on increasing the number of FP beneficiaries within lagging regions, potentially through initiatives similar to the current Horizon Europe pillar on *Widening participation and spreading excellence*. On the local level, authorities might consider

[6] An overview of the New European Innovation Agenda and its flagship initiative is available on the following website: https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/new-european-innovation-agenda_en

bolstering the presence of public research organizations (PROs) in partnerships, as they appear to serve as valuable innovation intermediaries, bringing FP beneficiaries closer to the local R&D network, and opening possibilities for knowledge cross-fertilisation. Yet, more research is needed to guide policy on preventing potentially reinforcing cycles in which FP beneficiaries leverage regional R&D funds to collaborate exclusively with other FP beneficiaries.

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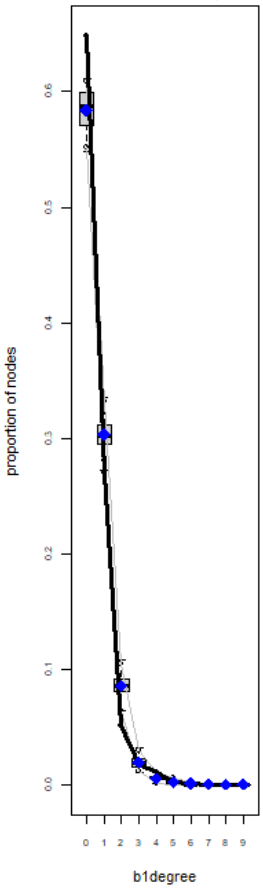
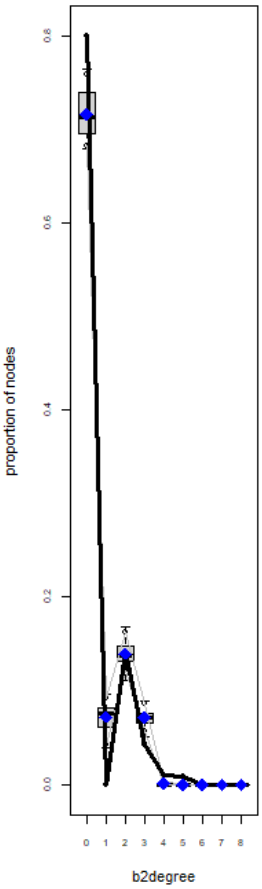
Appendix A.

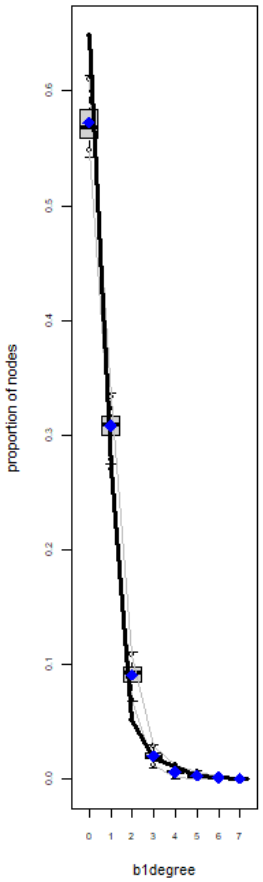
Below we present the visual goodness of fits for Models 1 through 5. The blue points in the plot represent the mean of statistics in the simulated networks, while the black line shows the observed statistics in the actual networks.

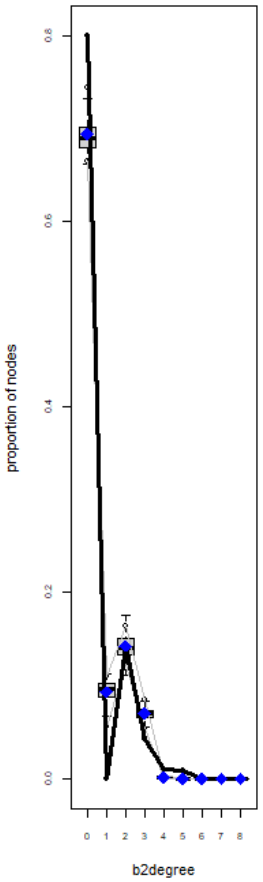
Goodness-of-fit diagnostic (Model 1)



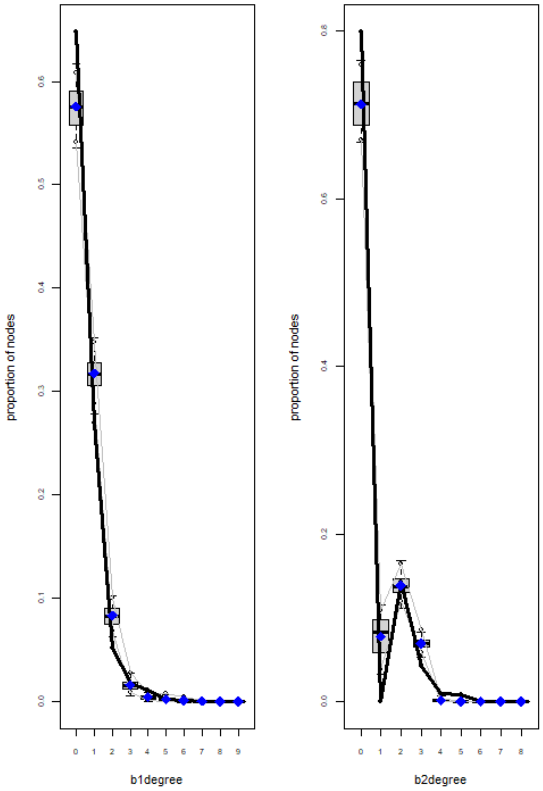


Goodness-of-fit diagnostic (Model 2)

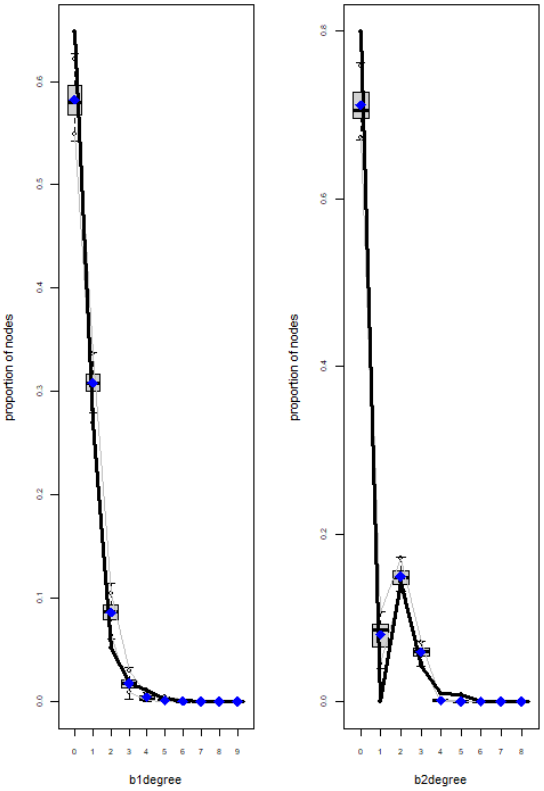




Goodness-of-fit diagnostic (Model 3)



Goodness-of-fit diagnostic (Model 4)



Goodness-of-fit diagnostic (Model 5)