PSL Quarterly Review

vol. 73 n. 293 (June 2020)

Article

Employment, innovation, and interfirm networks

ANDREA FABRIZI,* GIUSEPPE GAROFALO, GIULIO GUARINI and VALENTINA MELICIANI

Abstract:

This paper studies the employment impact of business network agreements, an innovative policy instrument introduced in Italy in 2010 to stimulate interfirm cooperation, with the aim of increasing innovative capacity and market competitiveness. We estimate the impact of these networks on employment for a panel of Italian firms using a system generalized method of moments and considering the literature on the employment impact of innovation. We find that networks, which can be interpreted as a form of open innovation, have a positive impact on employment; moreover, this impact appears positively influenced by sectoral and regional heterogeneity of firms and the region's innovation capacities. Overall, the results suggest that participation in networks where firms share industrial, commercial, and technical knowledge improves firm performance, creating synergies that help firms, especially small and medium-sized enterprises, to manage the growing complexity of knowledge and the fierce competition arising from increasingly globalized markets.

Fabrizi: Presidenza del Consiglio dei Ministri, Rome, email: a.fabrizi@governo.it
Garofalo: Tuscia University, Viterbo, email: garofalo@unitus.it
Guarini: Tuscia University, Viterbo, email: giulioguarini@unitus.it
Meliciani: Luiss Guido Carli, Rome, email: vmeliciani@luiss.it

How to cite this article:
Employment, innovation, and interfirm networks", *PSL Quarterly Review*, 73 (293): 161-180

DOI: https://doi.org/10.13133/2037-3643_73.293_4

JEL codes:
D85, J2, O36

Keywords:
interfirm networks, employment, innovation, GMM system

Journal homepage:
http: //www.pslquarterlyreview.info

The literature on the employment impact of innovation is rich in theoretical and empirical contributions.[1] However, the issue has recently gained new momentum in the face of two trends. On the one hand, with the information and communication technologies and digital revolutions, technological progress has accelerated its pace and enlarged and diversified its economic and employment impact; on the other hand, the long-lasting economic crisis has strongly increased unemployment in many developed countries, generating a new heated political debate. At the international level, the International Institute for Labour Studies (ILO, 2017) considers the inclusive growth as a win-win strategy where innovation is the channel through which the improvement of firms' performance is integrated with better labor conditions. The two pillars of the European Union strategy called "Europe 2020" are smart

* The views and opinions expressed in this article are those of the author and do not necessarily reflect those of the Presidenza del Consiglio dei Ministri.

[1] For a recent review, see Calvino and Virgillito (2018).

growth and inclusive growth, where targets related to innovation and employment are central in the monitoring and evaluation of the strategy's progress. In a globalized market, where firms compete on the basis of cost and technology, innovation can increase competitiveness without decreasing wages.

However, the increasing complexity of knowledge, in terms of both variety of competences and expertise, challenges the ability of firms to innovate by relying only on internal resources. Starting from this observation, Chesbrough (2003) has introduced the concept of open innovation, defined as collaboration with external partners to improve a firm's innovation capacity.

Unlike previous studies (Calvino and Virgillito, 2018), which mostly focus on the employment impact of firms' internal innovation strategies, this paper conducts a microeconomic analysis of the quantitative employment impact of open innovation. This topic is increasingly relevant due to the rise in both the complexity of knowledge and the flexibility of forms of organization for generating, transferring, and acquiring new knowledge (Lam, 2000). Moreover, the open innovation mode has a twofold innovative value: it represents an important organizational innovation, as well as an effective incubator of firms' innovation activities (Chesbrough, 2003 and 2006). However, while several empirical studies have looked at the influence of open innovation on firms' innovation performance (e.g., Laursen and Salter, 2006; Lazzarotti et al., 2015; Battisti et al., 2015) and on firms' financial and economic performance (Faems et al., 2010; Garofalo and Guarini, 2017),[2] the employment impact of this kind of innovation has been largely understudied; the only important exception is represented by the recent study of Triguero et al. (2020) that considers collaborations of Spanish manufacturing firms with universities, customers, suppliers and competitors. Therefore, this study contributes originally to the literature on the employment-innovation nexus by considering one of the main modes of open innovation, that is, interfirm networks, in Italy, based on innovation activities.

The Italian case is interesting because the productive structure of the country is characterized by the strong presence of small and medium-sized enterprises (SMEs) and by peculiar forms of collaboration known as the Italian industrial districts (Carbonara, 2018). Compared to these, which represent networks with formal elements (e.g., supply contracts) and informal elements (e.g., interpersonal relationships), the networks considered in our study, business network agreements (BNAs), are characterized by a formal structure within a well-defined regulatory context. This case study also has a general scope: indeed, the Organisation for Economic Co-operation and Development (OECD, 2014) evaluates these Italian networks as good practice.

In detail, we consider interfirm networks generated and structured by establishing specific contracts (BNAs, or "*contratti di rete*"), as defined in section 3. Our concept of open innovation, therefore, is limited to collaborations among companies and does not consider all the information sources coming from partners other than companies. While this can be a limitation of the paper, it allows for a focus on the interactive nature of knowledge exchanges, which is typical of networks and results in coupled open innovation (Gassmann and Enkel, 2004; Chesbrough and Bogers, 2014).

BNAs, introduced in 2010, are an innovative policy instrument for the Italian production system which stimulates collaboration between companies and allows them to realize shared

[2] See the survey by Greco et al. (2015).

projects and objectives with the aim of increasing their innovative capacity and competitiveness in the market while maintaining their independence, autonomy, and specialization. Using a large sample of Italian SMEs as a control group (more than 160,000 firms), Cisi et al. (2020) find that a BNA has a positive effect on some company performance indicators, such as a firm's gross margin ratio and exports, but not on profits. Using a smaller sample of Italian firms, Burlina (2018) finds similar evidence. Cisi et al. (2020) observe that advantages of this type of networking are stronger in the case of the following: smaller firms; firms operating in traditional markets; firms operating in turbulent markets; firms located in less developed areas; and firms not part of an industrial district.[3] Moreover, the characteristics of a network (such as its size, its geographical dispersion, and the sectorial diversity of its members) also have an impact on firm performance (see also Burlina, 2018).

Related to our analysis, Cisi et al. (2020) also find, using a fixed-effects models in which the dependent variable is the logarithm of the number of workers, a positive impact of a network variable (a dummy variable identifying the networking status of the firms, that is the year after the firm signs a network contract) on firm employment. Widening the analysis, considering a BNA as an expression of open innovation, we analyze the effects on employment of the companies involved within a model widely used in literature. To this end, we create an original database for the extensive period from 2008 to 2017 by combining the Bureau van Dijk Aida[4] database containing employment and balance sheet information with the InfoCamere database of firms belonging to networks. Following Van Roy et al. (2018), we estimate the impact of networks on employment for a panel of Italian firms using system generalized method of moments (SYS-GMM) in the context of the basic model used in the literature to test the employment impact of innovation.[5]

The research hypotheses tested are as follows: first, we estimate if open innovation has a positive employment impact; second, we test if regional and sectoral variety across partners of open innovation positively affects employment; third, always referring to employment-; finally, we consider the positive influence of regional innovation capacity on the employment impact of open innovation.

The paper is organized as follows. Section 1 reviews the literature and introduces testable hypotheses. Section 2 presents the empirical strategy. Section 3 describes the data and provides descriptive statistics. Section 4 discusses the results. The last section contains our concluding remarks.

[3] The BNAs were joined by companies that often had pre-existing relationships and that were located in district-intensive areas; however, the territorial boundaries of networks are often wider than traditional districts (Bentivogli et al., 2013): with the loss of the advantages of physical proximity and informal relationships (thanks to the ever wider use of communication technologies), relational proximity and formal relationships take on greater importance.

[4] Computerized analysis of Italian companies (*Analisi Informatizzata delle Aziende Italiane*), Bureau van Dijk, https://www.bvdinfo.com/it-it/our-products/company-information/national-products/aida?gclid= EAIaIQobChMI3ez -geah4AIV1ed3Ch193wWjEAAYASAAEgLV1_D_BwE.

[5] For a recent study using the same sample of firms signing network agreements and examining their impact on firm competitiveness, including employment, see Cisi et al. (2020).

1. Background literature and research hypotheses

1.1. Open innovation and interfirm networks

According to Chesbrough (2006, p.1), open innovation is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively." According to Enkel et al. (2009), there are three main open innovation processes: *outside-in processes,* where the firm enriches its knowledge by receiving new knowledge from customers, suppliers, and external knowledge sourcing; *inside-out processes,* where the firm obtains profits by externalizing its knowledge to the market, that is, by selling intellectual property; and *coupled processes,* where the firm co-creates with others partners, shares ideas and innovative activities and projects through alliances, cooperation, and joint ventures. Interfirm networks belong in the last category.

We indicate the following drivers of open innovation, according to the analysis of Gassman (2006). *Globalization* increases competition by reducing barriers and decreasing costs, and it accelerates technological change; therefore, open innovation can offer the opportunity to obtain economies of scale and competitive advantages more swiftly. The *technological intensity* of the process and product has risen to such a degree that open innovation permits (both small and large) firms to develop new technologies and to adapt to the fast technological pace. In this context, specialization in high-tech sectors facilitates cooperation in innovative activities. Prominent technologies such as mechatronics, optronics, and bioinformatics lead to *technology fusion*: the borders across industrial sectors fade and multidisciplinary knowledge becomes increasingly important; open innovation is thus a valid channel for obtaining the technological capabilities firms lack. From the abovementioned context arise *new business models,* to capture new business opportunities based on the sharing of business and investment risks and on mixing competences; open innovation has thus become one of the main pillars of this business paradigm. Finally, *knowledge leveraging* has become fundamental, due to the increasing relevance of knowledge and its mobility with the huge development and diffusion of open source software. Open innovation is therefore a way to cope with this relevant technological change, where knowledge is becoming more separable, codifiable, and sharable. Overall, given the abovementioned dynamics, open innovation enables firms to accelerate the innovation process by relying on external sources of knowledge (Dahlander and Gann, 2010; West and Bogers, 2014) and to face the technological and market challenges of remaining competitive (Enkel et al., 2009).

Specifically, for SMEs, open innovation is a strategic way of generating innovation, because their innovation capability is hampered by both internal and external barriers. The internal barriers are due to the scarcity of financial and human resources and to the low propensity to innovate and invest in research and development (R&D). The external barriers involve low capabilities of grasping market opportunities, due to limited customer insight and ineffective marketing strategies, and low technological capabilities, mainly due to difficulties in accessing new technologies and in evaluating the financial returns of innovative activity (Ndou et al., 2011). Moreover, especially for SMEs, networks are an instrument for resolving the insecurity deriving from continuous technological change by reducing the uncertainty of innovation (Diez, 2002). The levels of analysis for open innovation are "individuals, groups/projects, business units, ecosystems/communities, firms, regions or even national innovation systems" (West et al. 2014, p. 809).

This paper focuses on interfirm networks that are *alliance networks*, where firms formalize collaboration to innovate and whose soundness is based on frequent, repeated, and enduring interactions. Alliance networks differ from *contact networks*, where firms have merely informal relationships with each other (Huggins and Johnston, 2010).

1.2. Employment impact of open innovation

The vast literature on the effect of innovation on employment has pointed out different transmission channels and various possible outcomes according to the type of innovation and the level of analysis, such as firm, sector, or country (Calvino and Virgillito, 2018). Product innovation can have positive direct effects on employment by increasing value added. Process innovation can generally have negative direct effects in terms of labor savings through classic substitution between machinery and workers; however, it can also have an indirect positive effect by improving firm performance, thanks to decreases in prices. The size of this last impact increases with the price elasticity of demand and with competition within the market. Innovation also has two qualitative effects: the skill-biased nature of technological progress (Barbieri et al., 2019) and the skill bias of organizational innovation. Regarding organizational innovations, their employment impact is negative if they represent a rationalization of procedures and internal organization, whereas they positively influence employment when they involve structural and intensive changes that require new skills and competences (Evangelista and Vezzani, 2011).

In this sense, open innovation is a potentially positive employment driver, because it is skill biased in terms of new knowledge and abilities (Becker and Huselid, 2006; Coff and Kryscynski, 2011; Hunter et al., 2012). Moreover, open innovation can positively and indirectly affect employment by improving firm performance in numerous aspects, such as improvements in market research, the development of turnover from new businesses, enlargement of the product range, the provision of packet solutions to the consumer in the case of goods or service complementarities; increases in supply capacity, the reduction of entrance costs into new markets, the consolidation of market power, the enrichment of marketing activities, the activation of economies of scope to acquire certifications of quality, the reduction of procurement costs, and the implementation of benchmarking strategies (Sprenger, 2001).

Cisi et al. (2020) find that interfirm networks have a positive impact on employment associated with the improvement of competitiveness in terms of exports and gross margin ratios, while Garofalo and Guarini (2018) verify the positive employment impact of interfirm environmental networks at the regional level. Additionally, Powell et al. (1996) find firm alliances to have a positive influence on employment dynamics in high-tech sectors. A general analysis by the European Foundation for the Improvement of Living and Working Conditions (EuroFound, 2011) describes strategic alliance as having a positive impact, where interfirm networks are strongly conditioned by the size of firms and firms' sectoral and regional features.

The first hypothesis tested in this study is whether Italian interfirm networks (a type of open innovation) have a positive impact on firm employment, considering, unlike the abovementioned studies, a long period (2010-2017), by controlling for other relevant variables and accounting for endogeneity using a dynamic panel method (*f*).

H1: Open innovation has a positive impact on employment.

Overall, in closed innovation modes, spillovers are considered the side cost of business activity, whereas, in open innovation modes, spillovers represent business opportunities, becoming the core of the innovation activity and of its successful model (Chesbrough, 2012). Heterogeneity across members is the source of spillover. According to the survey of Burlina (2018), the heterogeneity of open innovation modes improves their performance impact, because it facilitates the diffusion and acquisition of different kinds of knowledge and exploits both technological complementarities and specialized competences and resources. Furthermore, current technological progress is mainly characterized by explorative innovation (Jansen et al., 2005), which is strictly linked with the heterogeneity of the network members. Explorative innovations are radical innovations concerning new products and services destined for new customers and new emerging markets, whereas exploitation innovations are incremental innovations oriented to consolidate existing customers and markets. The former is based more on the novelty of knowledge, competences, and skills, whereby cooperation with partners of different technological backgrounds becomes crucial. According to Johnson and Lundvall (1994), knowledge can be categorized into codified and tacit knowledge: the former concerns know-what and know-why and it is produced and transferred through formal channels; the latter concerns know-how and know-who, and it is produced and transferred through informal channels.

The heterogeneity of collaborative partners makes the generation of codified knowledge more effective. Indeed, the European Commission supports a great deal of research in multidisciplinary projects (Campbell et al., 2017). Collaboration across individuals with heterogeneous knowledge becomes necessary to gain new tacit knowledge, because social interaction is the only way to capture and acquire it. In particular, interfirm networks are founded on stable and enduring relationships of mutual trust, which are all elements relevant to the transfer of tacit knowledge. This aspect is very important because "all explicit knowledge presupposes tacit components" (Stokvik et al., 2016, p. 249).

Furthermore, creativity – conceptualized as both the ability to generate new ideas and the creative process and the outcome of this process – is the base of innovation activity, and it is enlarged and stimulated by multidisciplinary and multisectoral cooperation (Alves et al., 2007). Specifically, the studies of Nieto and Santamaría (2007) on Spain and of Zeng et al. (2010) on China verify that interfirm networks with high heterogeneity allow for the acquisition of diversified knowledge and the combination of different technological paths, improving the innovative performance of the firms. Moreover, new jobs are potentially driven by open innovation, where the diversity of work experiences and human capital is positively associated with openness, and this is a channel for hiring new workers (Bogers et al., 2018).

Given the information available in our database, as described in the next section, we verify the positive influence of the heterogeneity of open innovation on employment in terms of sectoral and regional diversity. Diversity across sectors can capture the variety of knowledge and competences due to different tasks and market structures, while diversity across regions can capture the diversity of regional innovation systems and, thus, different experiences and methods regarding innovative linkages. The second hypothesis is therefore as follows.

H2: The sectoral and regional heterogeneity of open innovation positively influences its employment impact.

The main regional context in which open innovation is developed can be crucial to its performance in terms of both technological linkages that favor open innovation, and technological dynamism and competition, which stimulate open innovation. Let us start by describing the former. Strong regional innovation performance is generally correlated with a high availability of skilled workers (Christopherson and Clark, 2007). Firms in high-technology sectors require high skills and competences, and high-skilled workers seek employment where it is better valorized (Florida, 2002). This kind of labor market facilitates innovation in general and open innovation in particular. High levels of regional research activity can be the product of fruitful relationships between the production system and the local institutions that sustain and promote innovation (Todtling and Trippl, 2005). Local institutions can facilitate the generation of open innovation through normative instruments (e.g., Italian business agreement contracts) and public funds, and they can offer opportunities to build networks; for instance, public calls to fund innovation projects can stimulate new collaborations across firms.

Moreover, the widespread spirit of innovation of firms starting new businesses stimulates the searching activities of network partners, and open innovation is favored by a financial system with a high propensity to support innovative entrepreneurship (Sengenberger et al., 1991). In other words, local technological changes are endogenous processes characterized by Schumpeterian competition mechanisms, factor substitution influenced by market changes, and Post-Keynesian demand pull pressures (Antonelli, 1998) and the outcome of open innovation can be enhanced by the exploitation of regional innovation resources.

According to the dynamic capabilities approach (Jiao et al., 2011), in a dynamic environment with rapid changes in technologies, markets, and competition, firms need dynamic capabilities, defined as capabilities "to integrate, build, and reconfigure internal and external resources and/or competencies to address their changing environments" (Teece et al., 1997, p. 516). To develop these capabilities, firms need an innovation strategy composed of management tools and processes, as well as routines, especially when the intensity and speed of changes imply instability and uncertainty. Therefore, open innovation can represent a useful innovation strategy for addressing technological challenges, especially in the case of SMEs, such that they can maintain or increase their market power with a proactive approach. In a dynamic environment, the obsolescence of products and services takes place suddenly (Jansen et al., 2005); therefore, explorative innovations become more relevant than exploitation innovations. This fact increases the necessity of developing new knowledge that can be promoted by open innovation. Overall, then, with the last hypothesis, we test if regional innovation capacity (proxied by the average regional percentage of researchers employed within firms) positively moderates the impact of open innovation (represented by Italian interfirm networks) on employment.

H3: Regional innovation capacity favors the employment impact of open innovation.

2. Business network agreements

As already highlighted in the introduction, the *contratto di rete*, or BNA, introduced in 2010, represents an innovative policy instrument[6] for the Italian production system. It stimulates collaboration between companies and allows them to realize shared projects and objectives while maintaining their independence, autonomy, and specialization, with the aim of increasing their innovative capacity and competitiveness on the market (see also Cisi et al., 2020). This institution is characterized by a series of elements: the plurality of its participants (two or more); a common network program in which the participating entities agree to cooperate in predetermined forms and areas related to the exercise of their activities; the exchange of information or services of an industrial, commercial, technical, or technological nature; the joint exercise of one or more activities falling within the scope of business; cost sharing, staff sharing, access to non-repayable loans, and tax benefits; establishment of a common wealth fund; and the appointment of a body responsible for managing the execution of the contract in the name and on behalf of the participants.

All these elements can be found in the *contratto di rete* signed by the companies in different forms, depending on the object and purpose of the contracts themselves: these contracts can, for example, provide only a common network program or exchange information. Additionally, the choice to set up a common equity fund is optional; in the case of such a fund's implementation, together with the creation of the co-management body, the contract acquires its own legal subjectivity (*rete soggetto*).[7]

Specifically, as of 23 June 2018, 4,002 contracts have been signed,[8] for a total of 21,873 contracting parties, corresponding to 19,944 participating companies,[9] highlighting a positive growth trend since the establishment of the BNA in 2010, as shown in table 1.

As for companies required to deposit their balance, it was possible to connect the two databases InfoCamere and AIDA,[10] thus obtaining the economic-financial data for 12,146 of the 19,944 companies signing BNAs for the period 2008-2017.

With this InfoCamere/AIDA database built as described above, it is therefore possible to investigate, among other things, the effects of network contracts on companies' employment with the econometric model presented in the following section for a sample of 7,179 companies with 21,364 observations (unbalanced panel).

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[6] "In recent years, Parliament has decided to intervene in the networks of companies, especially to increase competitiveness of the companies themselves and to overcome in part the limitations resulting from our productive structure, which is made up of small and very small companies. In fact, by participation in the network, companies become part of a large system and can benefit from the economies of scale of the large system to which they belong. More specifically, they increase their ability to invest in research and development, extend their demand, open up sales services abroad and increase the range of products/services offered. Networks can involve both districts and production chains and can also activate collaborations with research or training centers" [our translation from notes of the Italian Parliament]. Source: http://leg16.camera.it/561?appro=518&Distretti+produttivi+e+reti+di+imprese.

[7] The *rete soggetto* does not fall within the scope of this analysis.

[8] Source: InfoCamere, http://contrattidirete.registroimprese.it/reti.

[9] The difference between the number of contracting parties and the number of participating companies is due to the fact that some firms can take part in more than one contract.

[10] Computerized analysis of Italian companies (*Analisi Informatizzata delle Aziende Italiane*), Bureau van Dijk, https://www.bvdinfo.com/it-it/our-products/company-information/national-products/aida?gclid=EAIaIQobChMI3ez -geah4AIV1ed3Ch193wWjEAAYASAAEgLV1_D_BwE.

Table 1 – *Business network agreements, 2010-2018*

	Number of new BNAs	In % of the total	Number of contracting parties	In % on the total	Average number of contracting parties per BNA
2010	18	0.45	95	0.43	5.28
2011	153	3.82	780	3.57	5.10
2012	305	7.62	1,511	6.91	4.95
2013	573	14.32	2,646	12.10	4.62
2014	392	9.80	2,266	10.36	5.78
2015	521	13.02	2,768	12.65	5.31
2016	680	16.99	3,362	15.37	4.94
2017	978	24.44	5,409	24.73	5.53
2018	382	9.55	3,036	13.88	7.95
Total	4.002	100.00	21,873	100.00	5.45

Source: elaboration of data from InfoCamere, http://contrattidirete.registroimprese.it/reti.

Table 2 summarizes the geographical, sectoral, and dimensional features of the companies.

Table 2 – *Company classifications*

	NW	**NE**	**CN**	**South**	**Total**
Business sectors					
Agriculture/Fishery	70	134	141	188	533
Industry/Handicraft	3023	2954	2164	2001	10142
of which Manufacturing	*2397*	*2474*	*1749*	*1457*	*8077*
Other Sector	22	23	31	45	121
Service	2,219	1,940	2,164	1,595	7,960
Trade	578	554	360	445	1,937
Tourism	94	200	161	216	671
Total	6,006	6,071	4,797	4,490	21,364
Enterprise classifications					
Small	4,707	4902	3987	3,854	17,450
Medium-Size	923	815	630	499	2,867
Large	376	354	180	137	1,047
Total	6,006	6071	4797	4,490	21,364

Source: elaboration of data from InfoCamere, http://contrattidirete.registroimprese.it/reti and AIDA database https://www.bvdinfo.com/it-it/our-products/company-information/national-products/aida?gclid=EAIaIQobChMI3ez -geah4AIV1ed3Ch193wWjEAAYASAAEgLV1_D_BwE.

Notes: NW = Liguria, Lombardia, Piemonte, Valle d'Aosta; NE = Emilia-Romagna, Friuli-Venezia Giulia, Trentino-Alto Adige/Südtirol, Veneto; CN = Toscana, Umbria, Lazio, Marche; South = Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia, Sardegna, Sicilia. See Appendix C for correspondence table between Business Sector and NACE Rev. 2 classification. Small enterprises are those with 10-49 persons employed and annual turnover of up to EUR 10 million; medium-sized enterprises are those with 50-249 persons employed and annual turnover of up to EUR 50 million; large enterprises are those with 250 or more persons employed and annual turnover over EUR 50 million.

The data in table 2 reflect the characteristics of the Italian business sector: a predominant presence of firms in the northern part of the country and strong relevance of small enterprises, particularly in the south (ISTAT, 2015).

To verify whether regional innovation capacity favors the employment impact of open innovation, we integrate the database with the variable representing "researchers employed in companies over the total number of employees" (ind416),[11] derived from the ISTAT territorial indicators database for development policies.

3. Empirical specification, data, and econometric methodology

The econometric analysis focuses on the effects of open innovation on the employment of participating companies, following the theoretical framework set out in the previous paragraphs. To test our hypotheses, we use a dynamic stochastic version of a standard labor demand equation, augmented by including our variable for open innovation (for similar specifications, see Barbieri et al., 2019; Bogliacino et al., 2012; Lachenmaier and Rottmann, 2011; Van Reenen, 1997; Van Roy et al., 2018). Our baseline specification (related to H1) is

$$Emp_{it} = \beta_0 + \beta_1 Emp_{it-1} + \beta_2 VA_{it} + \beta_3 W_{it} + \beta_4 Inv_{it} + \beta_5 NET_{it} + \varepsilon_i + v_{it} \quad (1)$$

for firm $i = 1, \dots, n$ and reference year $t = 2010, \dots, 2017$, with all variables expressed in logarithmic terms. Equation (1) allows us to analyze the employment trend and its determinants for our sample of companies.

Our dependent variable (Emp) is the natural logarithm of the number of employees in the firm. The explanatory variables of the models are firm output, labor cost, and tangible fixed investments. We measure firm output as the natural logarithm of value added (VA), and investment as the annual rate of growth in tangible fixed assets (Inv); finally, labor costs are measured as the natural logarithm of the gross wage per employee (W). Value added, tangible investment, and labor costs are deflated using the national gross domestic product deflator centered on the year 2010. While we expect labor costs to have a negative impact on labor demand, the output is expected to contribute with a positive sign, while the effect of investment is ambiguous, since capital formation can have two opposite effects: labor expanding, stimulating, and accompanying the company's dimensional growth and/or labor saving through process innovation embodied in new machinery (Piva and Vivarelli, 2018).

Our empirical counterpart of open innovation is the variable NET_{it} , which corresponds to the sum of the links/collaborations activated with the other $n-1$ companies participating in the BNAs signed by firm *i*. We also construct two other variables that, respectively, capture the sectoral and regional intensity expertise flows generated in the BNAs: $SecNetInt_{it} = \frac{SecNet_{ist}}{NPart_{it}}$ and $RegNetInt_{it} = \frac{RegNet_{ist}}{NPart_{it}}$, where $SecNET_s$ ($RegNET_r$) corresponds to the sum of the links/collaborations activated with the other $n-1$ business sectors (regions) participating in BNAs signed by firm *i*, and $Npart$ is the number of firms that firm *i* is participating with in the BNAs.

The variable NET measures the intensity of the network driver for innovation and, therefore, the effect of companies' participation in network contracts. The regional and sectoral variables $RegNetInt$ and $SecNetInt$, respectively, consider the heterogeneity of the

[11] Source: https://www.istat.it/it/archivio/16777.

interactions, because they measure the sum of the connections activated with the other $n-1$ companies (regions or sectors) participating in the network contracts. These variables can be considered proxies of the shared competences (knowledge, know-how, and resources) acquired by the company and can capture the impact of the factors linked to open innovation, as discussed above.

The variable $ResInt$ is the regional innovation capacity, proxied by the average regional percentage of researchers employed in firms.

Appendix A reports the descriptive statistics and correlation matrix of all the variables.

The dynamic specification (1) is characterized by an obvious endogeneity problem. To address it, following Van Roy et al. (2018), we estimate all equations using the SYS-GMM approach developed by Blundell and Bond (1998). Hence, estimates are obtained by a system of simultaneous equations in first differences and in levels, with the level equations also including a set of dummy controls (time, size, business sector, and regional dummies).

Indeed, our choice of instruments is as parsimonious as possible (Roodman, 2009a and 2009b), once we take into account the outcomes of the autocorrelation tests AR(1) and AR(2). Specifically, as instruments for the level equations, we use the differenced values of the independent variables – that is, twice-lagged differences in employment, output, tangible investment, labor and environmental networks, the logarithms of the number of BNAs, and year, dimensional, sectoral, and regional dummies—as controls. For the difference equations, we use the twice-lagged values of the above-mentioned explanatory variables as instruments for most of the models, to reject the null hypothesis of no autocorrelation (see the AR(1) and AR(2) tests reported in tables 3 and 4). To maximize the sample size, we use orthogonal deviations to reduce the problem of gaps in variables (Roodman, 2009a).

The dummy variables $Size, Sectors$, $Time$, and $Regions$ capture differences in employment by size (small, medium-sized, and large enterprises) across sectors, following the 2007 Classification of Economic Activity (ATECO 2007),[12] over time and across regions.[13] Time dummies can capture trends in the economic cycle, while regional dummies capture spatial heterogeneity, which is very strong in Italy (Mazzanti et al., 2012).

In this empirical analysis of the employment dynamic, the temporal, size, and sectoral dummies can capture specific phenomena. First, during the economic cycle, firms have a lagged reaction in terms of labor demand when the first changes become trends, because every change in employment implies economic costs: a negative market signals so-called labor hoarding, and positive economic signals after a crisis indicate that labor demand is awaiting changes in trends. Second, every sector (and every firm size) distinguishes itself from the others in terms of competition level, relevance of product or process innovation, and potential mechanisms of employment compensation, and all these factors influence the employment dynamic (Calvino and Virgillito, 2018). Third, different regional contexts influence firms in terms of human capital supply and financial innovation support. Finally, β_0, ε_i, and v_{it} are, respectively, a constant, an idiosyncratic individual and time-invariant firm fixed effect, and a white noise residual.

[12] ATECO 2007, at the macro level, consists of agriculture/fishery, industry/handicraft, other sectors, services, trade, and tourism (see also Appendix B).

[13] Regional dummies are included at different territorial levels. Usually, we consider the 20 Italian regions, but in some cases we use the more aggregate classification of northeast, northwest, center, and south, based on Hansen's test's results.

4. Main results

Tables 3 and 4 show the regressions carried out by SYS-GMM estimation. Overall, the results are coherent with the conceptual framework and with the specific research hypotheses illustrated in the previous sections.

Table 3 – *Results from GMM-SYS analysis on the relation between employment and open innovation mode*

	(1)	(2)	(3)	(4)
Empit-1	0.426***	0.382***	0.410***	0.440***
	(15.58)	(13.33)	(8.40)	(12.80)
VAit	0.470***	0.414***	0.321***	0.428***
	(15.25)	(12.28)	(8.45)	(12.54)
Wit	-0.374***	-0.349***	-0.184***	-0.333***
	(-7.76)	(-7.42)	(-2.70)	(-8.12)
Invit	0.112**	0.124***	0.130**	0.0803*
	(2.36)	(2.77)	(2.34)	(1.72)
Netit	0.0352***	0.0320***	0.0490***	0.0302**
	(3.60)	(3.18)	(2.89)	(2.58)
Time dummies	Yes	Yes	Yes	Yes
Sectoral dummies	No	Yes	No	No
Size dummies	No	Yes	Yes	Yes
Regional dummies	No	Yes	Yes	Yes
Constant	-3.633***	-2.148***	0	-2.884***
	(-11.83)	(-4.42)	(.)	(-5.64)
Observations	21364	21314	8051	7950
Number of firms	7179	7176	2348	2832
Instruments	116	141	136	136
Hansen test (*p*-value)	0.501	0.384	0.936	0.777
AR1 (*p*-value)	1.15e-44	2.31e-39	4.03e-17	1.02e-29
AR2 (*p*-value)	0.393	0.606	0.291	0.384

*, **, *** indicate 10%, 5% and 1% significance levels.

Notes: One-step GMM robust standard errors; ; *z* statistics in parentheses. In the Hansen *J* test statistic for overidentifying restrictions, the null hypothesis (H0) is that all overidentifying restrictions are jointly valid, so when the *p*-value is larger than the significance level (e.g., 0.1 or 0.05) we can accept H0 and conclude that our instruments may be valid (exogenous) As the Hansen test can over-reject the null in case of very large samples (Van Roy et al., 2018, p. 1767), we performed random sub-sample tests for 10% of the original data in columns 1 and 2 and we reported the *p*-value in the table.

Table 4 – *Results from GMM-SYS analysis: on the relation between employment, open innovation mode and regional and sectorial features*

	(1)	(2)	(3)
Empit-1	0.372***	0.386***	0.416***
	(11.33)	(11.84)	(14.48)
AVit	0.410***	0.407***	0.473***
	(11.01)	(11.27)	(14.05)
Wit	-0.368***	-0.341***	-0.320***
	(-6.80)	(-6.45)	(-6.68)
Invit	0.109**	0.111**	0.115**
	(2.35)	(2.43)	(2.34)
RegNetIntit	0.0948***		
	(3.04)		
SecNetIntit		0.0555*	
		(1.68)	
Netit			0.0922**
			(2.48)
ResIntit			-0.140*
			(-1.78)
ResIntit x Netit			0.0599*
			(1.81)
Time dummies	Yes	Yes	Yes
Sectoral dummies	Yes	Yes	Yes
Size dummies	Yes	Yes	Yes
Regional dummies	Yes	Yes	No
Constant	-2.134***	0	0
	(-4.09)	(.)	(.)
Observations	21314	21314	18208
Number of firms	7176	7176	6351
Instruments	126	126	123
Hansen test (*p*-value)	0.116	0.336	0.214
AR1 (*p*-value)	6.05e-26	3.81e-25	5.15e-41
AR2 (*p*-value)	0.331	0.376	0.585

*, **, *** indicate 10%, 5% and 1% significance levels.

Notes: One-step GMM robust standard errors; *z* statistics in parentheses . In the Hansen *J* test statistic for overidentifying restrictions, the null hypothesis (H0) is that all overidentifying restrictions are jointly valid, so when the *p*-value is larger than the significance level (e.g., 0.1 or 0.05) we can accept H0 and conclude that our instruments may be valid (exogenous). As the Hansen test can over-reject the null in case of very large samples (Van Roy et al., 2018, p. 1767), we performed random sub-sample tests for 10% of the original data in column 3 and we reported the *p-value* in the table.

A first general finding is that employment is path dependent. In all the equations, the coefficient of the lagged variable *Emp* is significant and positive. This finding confirms that firms' performances are strongly dependent on the past (Antonelli and Colombelli, 2015) and that changes in the labor market are slow: a positive or negative inversion of economic trends has a lagged impact on the firms' labor strategy. Because of both the uncertainty of demand dynamics and the costs of changes, the employment strategies of firms are path dependent (Burnside et al., 1990). The basic model of Van Roy et al. (2018) is verified in all the equations, since the coefficients of *VA* and *Inv* are positive and significant, while the coefficient of *W* is

significant and negative. These results validate the Keynesian mechanism of effective demand and also show that it is the main driver of employment: in every equation, the positive coefficient of *VA* is the highest.

Moreover, these results confirm that capital and labor can be either substitutes or complements, depending on the firm's investment strategy. Increases in wages can stimulate investment to increase efficiency by saving on labor costs and increasing the mechanization of production processes, and firms can make investments to enlarge production capacities by increasing both productive factors, capital and labor.

The estimates of equations (1) to (4) in table 3 support H1. Indeed, in all of the equations, the coefficient of *Net* is significant and positive. Open innovation is an effective instrument for employment: it consists of radical organizational innovation with skill bias, because it spurs the hiring of workers with new skills and competences; on the other hand, it promotes and supports innovation activities with a positive effect on performance and, consequently, on employment. Specifically, the positive impact on employment of Italian interfirm networks based on business agreement contracts illustrates the effectiveness of a policy instrument conceived to support Italian SMEs facing the challenges of globalization. This policy instrument validates the win-win strategy according to which innovation is the channel that can combine competitiveness with employment goals.

Equation (1) presents the base model with only time dummies, while, in equation (2), sectoral, regional, and size dummies are included, all of which are used in the following regressions. All the types of dummies considered can capture specific and relevant phenomena linked to the innovation-employment nexus. Time dummies capture the employment impacts of the economic cycle with reference to general macroeconomic conditions. According to Peters et al. (2014), who analyze the Community Innovation Surveys of 26 European countries up until its 2010 wave, in times of recession, product innovators are more resilient, with lower employment losses, with respect to product non-innovators. Sectoral dummies can control for heterogeneity across sectors in market regimes, the relevance of product or process innovation, and potential mechanisms of employment compensation (Calvino and Virgillito, 2018). Regional dummies can capture regional variety in terms of market regulations and social and economic factors that can influence firms' employment strategies.

Equations (3) and (4) strengthen the abovementioned results by considering the manufacturing and services sectors, respectively. These regressions are interesting because studies highlight differences between these two sectors in terms of innovation. According to Peters et al. (2014), the performance impact of product innovation appears to be more effective in the services sector, whereas, according to Harrison et al. (2014) using the CIS survey for France, Germany, the United Kingdom, and Spain in the period 1998-2000, the services sector seems to have a lower propensity to innovate.

In table 4, equations (1) and (2) are consistent with H2: the coefficients of both *RegNetInt* and *SecNetInt* are positive and significant, such that regional and sectoral heterogeneities across the members of networks generate spillovers with a positive employment impact. This result confirms that one of the main pillars of open innovation is the expansion of partner variety (Chesbrough, 2017). Specifically, the results on sectoral heterogeneity suggest the importance for firms of involving customers and/or suppliers in their innovation activities, whose success depends more on their successful adoption by users and customers than on the creation process per se (European Commission, 2018).

The results on regional heterogeneity confirm that, in the age of globalization, spillovers deriving from territorial openness are crucial. Indeed, according to De Marchi and Grandinetti (2014), in a globalized economy, economies of localization and resources embedded in an industrial district are not sufficient to remain competitive, and the survival of SMEs and their networks depends on outside spillover. In this sense, business agreement contracts have been conceived to overcome these limits and promote a new form of aggregation more adapted to a globalized dynamic market (Burlina, 2018). Overall, H2 points out that policies should sustain a variety of network partners (Menzel and Fornahl, 2010). For instance, European Union-funded framework programs unify the abovementioned aspects: they promote heterogeneity in terms of internationalization and in terms of institutional sectors by involving firms, public research centers, and universities (Fabrizi et al., 2018).

Finally, the results of equation (3) support H3. The coefficient of *ResInt×Net* is significant and positive. Regional innovation capacity enhances the positive impact of collaboration on employment. On the one hand, firms receive positive spillovers from an innovative regional system in terms of highly skilled employees in the labor market and financial and institutional support of innovation and technological linkages (Christopherson and Clark, 2007; Sengenberger et al., 1991; Todtling and Trippl, 2005); on the other hand, high levels of regional innovation capacity can lead to a more intensive technological competition that pressures firms to innovate (Jiao et al., 2011; Teece, 2007; Teece et al., 1997). However, SMEs, which represent the great majority of enterprises in our sample, can be at a competitive disadvantage when operating in a very innovative context, given their knowledge and resources constraints. This last effect appears to be confirmed by the negative and significant coefficient of *ResInt*. Thus, the positive interaction between regional innovation capacity and interfirm networks highlights that open innovation can represent the main instrument in developing a successful innovation strategy for SMEs. In other words, without open innovation, firms, mainly SMEs, risk losing employees, especially when operating in research-intensive contexts.

5. Concluding remarks

In this paper, we have investigated the employment impact of a new contractual form, the BNA, an innovative policy instrument introduced in Italy in 2010 to stimulate interfirm cooperation, with the aim of increasing innovative capacity and market competitiveness. We have found that such networks favor employment creation in both the manufacturing and services sectors. We interpret participation in these networks as a form of open innovation strategy, since BNAs involve the exchange of information or services of an industrial, commercial, technical, or technological nature. Therefore, the empirical results support the view that open innovation can positively affect employment by improving firm performance and creating innovation synergies that help firms, especially SMEs, face the increasing complexity of knowledge and the fierce competition arising from increasingly globalized markets.

A second important result of the empirical analysis is the positive impact on employment of heterogeneous networks in terms of both regional and sectoral participation. On the one hand, this result confirms the positive role of the breadth of knowledge in open innovation strategies (Laursen and Salter, 2006), and, on the other hand, it suggests that new forms of organization going beyond the logic of industrial districts and drawing on differentiated

regional competences could be necessary to address competition in increasingly globalized markets.

Finally, network participation is more effective for employment creation when firms operate in more R&D-intensive regions. This last finding underlines that open innovation is particularly important for (small) firms operating in highly innovative contexts.

The results of this study suggest that organizational innovations are fundamental for productive systems based on SMEs to reconcile international competitiveness with employment creation, and that new forms of contracts involving the sharing of different types of competences are a viable tool to achieve this goal.

The empirical analysis has tried to take into account the context, according to the availability of data, by controlling for sectoral, size and geographical dummies and by adding a variable measuring regional innovative capacity. Further analyses could investigate in more detail the extent to which contextual factors affect the BNAs' performances. Indeed, the literature considers the developmental effects of external networks strictly linked with social, economic, and institutional peculiarities of a territory as well as with the macroeconomic factors and, consequently, successes and failures of a network model are strongly context sensitive. Indeed, the design of a network should be adapted to the context to avoid both market failures and government failures (Bentivogli et al., 2013). Moreover, while we have found that the heterogeneity of actors helps within a country, future investigations could assess whether intra-European business networks could be used to strengthen the competitiveness of the European production system and to reconcile international competitiveness, innovation, and employment creation.

Overall, the results of this paper have relevant policy implications that can stimulate further empirical studies. Firstly, networks sustaining innovation activities can increase labor demand and stimulate employment. This aspect encourages business and policy strategies to achieve the so-called inclusive growth (ILO, 2017) that makes technological competition more socially sustainable than cost competitiveness, where workers' bargaining power is weakened (Pianta, 2000 and 2001). Secondly, although we find a positive role of networks for employment creation, the amplifying impact of the regional context could be further investigated. An interesting avenue to follow could be the investigation of possible complementarities between BNAs and other traditional labor market policy instruments. Thirdly, due to lack of data, in this study we have not investigated to what extent BNAs might stimulate different types of innovation (product, process, organizational, etc.). This is an important question that has to be addressed in order to better disentangle the transmission mechanisms linking participation in BNAs to employment creation. A deeper study of the impact of BNAs on innovation could contribute an assessment of whether they play a potential role as a bailout instrument for risky or exploratory investments and partnerships.

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Appendix A

Table A1 – *Description of the variables*

Variable	Description
Employment (Emp)	Number of employees
Output (AV)	Gross value added (millions)
Labor (W)	Labor cost per employee (thousands)
Investment (Inv)	Growth rate in tangible fixed assets
Net	Number of the company's links in business network agreements
RegNetInt	Regional net intensity
SecNetInt	Sectoral net intensity
ResInt	Regional average percentage of researchers employed in firms

Table A2 – *Summary statistics*

Variable	Obs.	Mean	Std. dev.	Min	Max
Emp	21,364	60.669	523.908	1	33636
Empt-1	21,364	58.572	509.674	1	33636
VA	21,364	3223.206	26191.780	0.105	1959247.000
W	21,364	26.887	254.101	0.008	37026.430
Inv	21,364	0.0297	0.571	-8.246	6.797
Net	21,364	9.3817	12.182	1	334.000
RegNetInt	21,364	25.643	20.127	1	88.500
SecNetInt	21,364	10.442	15.937	1	86.714
ResInt	18,251	0.3667	0.150	0.028	0.762

Table A3 – *Correlation matrix (21,364 observations)*

	Empt	*Empt-1*	*AV*	*W*	*Inv*	*Net*	*SecNetInt*	*RegNetInt*	*ResInt*
Emp	1								
Empt-1	0.9901	1							
VA	0.7351	0.7234	1						
W	–0.005	0.0288	0.0028	1					
Inv	0.0054	0.0036	0.0026	–0.0307	1				
Net	0.0185	0.0192	0.0222	–0.017	–0.017	1			
SecNetInt	0.0444	0.0433	0.0424	–0.0007	0.002	–0.0058	1		
RegNetInt	–0.0234	–0.0204	–0.0204	–0.0106	–0.0106	–0.1521	0.0183	1	
ResInt	0.0546	0.0541	0.0592	0.0066	0.0053	–0.0281	0.0202	–0.0651	1

Appendix B

Table B1 – *Correspondence table between business sectors and the NACE Rev. 2 classification*

Agriculture/Fishery
- A – Agriculture, Forestry and Fishing

Industry/Handicraft
- B – Mining and Quarrying
- C – Manufacturing
- F – Construction
- G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
- S – Other Service Activities

Services
- D – Electricity, Gas, Steam and Air Conditioning Supply
- E – Water Supply; Sewerage, Waste Management and Remediation Activities
- F – Construction
- H – Transportation and Storage
- J – Information and Communication
- K – Financial and Insurance Activities
- L – Real Estate Activities
- M – Professional, Scientific and Technical Activities
- N – Administrative and Support Service Activities
- P – Education
- Q – Human Health and Social Work Activities
- R – Arts, Entertainment and Recreation
- S – Other Service Activities

Tourism
- I – Accommodation and Food Service Activities
- N – Administrative and Support Service Activities

Trade
- G – Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
- I – Accommodation and Food Service Activities

Other Sector
- I – Accommodation and Food Service Activities
- S – Other Service Activities