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«Relations at Work» in a Modern Industrial District: A Pathway to Innovation

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In this paper, we focus on how firms' propensity to innovate in industrial districts is related to the knowledge dynamics entailed by their relational assets. We integrate the well-established knowledge-based theory and the open innovation literature with consideration of the so-called «knowledge relations spiral». How knowledge is created, transferred and diffused in an industrial district and how new knowledge and innovations are generated in the process are widely explored issues, we propose however an *operational* approach to the key concepts in the relevant literature and we test them on a case district: the Apulian Clothing Industrial District for the year 2012. To this end, we consider a multi-stage econometric model, based on a system of simultaneous equations spanning across 1) the influence of firms' relational choices on district innovative performance and 2) the influence of district firms' innovative effort and structural characteristics on their relational choices.

Data are derived by administering a questionnaire to a selected sample of district firms.

The results support the presence of a «knowledge relations spiral» at work within the district, generating a continuous exchange of tacit and codified knowledge both within and outside it. In this way an innovation process is created. Finally, the analysis suggests a more proactive role of the institutions to favor the reproduction of the industrial district over time.

Keywords: Knowledge, Industrial District, Innovation, Internal and External Relations
Classificazione JEL: L25; L2; D83

1. INTRODUCTION AND RELATED LITERATURE

Knowledge is a complex concept that reflects the theoretical or practical understanding of a subject and the facts and skills acquired through experience or education. For simplicity, knowledge can be reduced into two main dimensions, explicit and tacit knowledge, which are present at both the individual and social levels (Polanyi, 1962a; 1962b; 1983). Tacit knowledge

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includes cognitive features or mental models, technical aspects (Nonaka, Takeuchi 1995) and critical elements (Howells, 2002). Explicit, codified or articulated knowledge (Busch, Richards 2003), instead, involves know-how that is transmittable in a formal and systemic language. It is objective, and it is in the mind since it is the knowledge of rationality.

Many theories exist to explain the transfer and the transformation from personal and/or individual knowledge to social knowledge and from organizational knowledge to inter-organizational knowledge or district-knowledge [1]. If it is «easier» to understand the first process (individual-social), the second is more complex to explain. The route to a new way of conceiving the knowledge base of the firm is founded upon resource-based theory and attributed to Penrose (1959). This author notes the importance of experience (learning by doing) and codified and transmissible knowledge and focuses on the resources that one firm owns. However, she does not elaborate on how and why this knowledge is transmitted and accumulated within the firm. Instead, the relational view (Polanyi, 1962a; Howells, 2002; Metcalfe, Ramlogan 2005; Foray, 2006; Giuliani, Bell 2005; Ter Wal, 2013) extends and complements resource-based theory, and it explains innovation in a cluster (Harvas-Oliver, Albors-Garrigos 2009, p. 264). Within this framework, industrial firms improve performance based on relationships with frequent interactions, and acquaintance, as well as social networks or ties (Granovetter, 1973; Burt, 1992; Powell, Grodal 2005), fosters learning by interaction (Lundvall, 1992; Antonelli, Nosvelli 2008; Belussi, Sedita 2012), learning by doing (Penrose, 1959; Arrow, 1962), and learning by using (Rosenberg, 1982). In such a context, innovation is understood as an interactive learning process that is socially and territorially embedded and culturally and institutionally contextualized (Lundvall, 1992).

Firm knowledge is not completely observable because it is intangible, and only the tangible aspects of it such as rules and technologies can be observed. Only information is transferred (Barney, 1991; Howells, 2002). Noticeably, firms and organizations have no self-knowledge in the direct sense (Habeck *et al.*, 2000), and the transferability and imitability of their know-how are influenced by several characteristics or dimensions such as codifiability and complexity (Rogers, 1983; Winter, 1987) [2].

[1] For an extensive review, see de Felice *et al.* (2012).

[2] Codifiability is the ability of the firm to structure knowledge into a set of rules and relationships that can be easily transmitted. Complexity refers to the number of operations required to solve a task, or the number of parameters needed to define a system. Rogers (1983) and Winter (1987) explore how knowledge may be recombined through internal and external learning to form a combinative capability; they presume, therefore, that firm knowledge is socially constructed. Foss (1996), instead, considers complexity, tacitness and specificity as characteristics of capabilities that include the tacit and social components of firm knowledge.

Powell and Grodal (2005) hold a different point of view, according to which knowledge can be shared within the firm among/through interpersonal networks. The organization and the internal structure of the firm form a social system, where relationships depend on both interpersonal and inter-organizational ties. Although these channels allow information to be tangibly shared – e.g., publication and patents – it might be difficult to transfer it between different firms (Kogut, Zander 1997). A partner might choose to protect a particular innovation or a competitive advantage. Thus, when knowledge contains a large tacit dimension, its value is high, and its dissemination is partial and extremely costly, while when the explicit dimension prevails, the value of the knowledge is lower, and the transfer is costless (Richardson, 1972; Powell, Grodal 2005). This suggests that there exists «[...] a medium level of codified knowledge where the value of the innovative output exceeds the costs of knowledge transfer [...]» (Powell, Grodal 2005, p. 76). Codified knowledge is more accessible, but its interpretation and assimilation are influenced by geographic space (Krugman, 1991). Within the clusters, cognitive factors and production processes play a specific role in the formation of these industrial organization (Mistri, 2010). When firms are spatially clustered, knowledge externalities will be more common (Cainelli, Lupi 2011). Thus, the concentration of firms or their spatial proximity influence knowledge interactions (Mistri, 2010; Howells, 2002).

This representation of industrial districts (IDs) is considered by one stream of the literature (Brusco, 1991; Bellandi, De Propris 2015; Dei Ottati, 2018) to apply to the second generation of IDs, and which are labelled Marshallian Industrial Districts (MIDs) or IDs Mark 2 [3]. The Marshallian firm district, in its canonical form, finds it difficult to evolve, as its work is stable and historically anchored to the local system. The Marshallian district is, in its functional logic, ordered and regular, and it evolves without jumps or radical discontinuity (Ferrucci, 1999).

Cooperation and worker mobility between firms of an ID can originate new knowledge and innovation. The creation and diffusion of knowledge in a district depends on confidence and trust among the members of the district, learning processes based on imitation, inter-organizational relationships, resource sharing (Powell, Grodal 2005) and interactions between agents with different levels of knowledge and competence (Cappellin, 2001).

[3] Bellandi and De Propris (2015, p. 2) distinguish three generations of industrial districts (IDs) – respectively IDs Mark 1, IDs Mark 2 and IDs Mark 3 – «representative of three waves of industrialization in which they have played an important and distinctive role. During the first wave, IDs were the seed-beds and first-comers of the industrial revolution. The second wave refers to the re-emergence of the role of IDs within developed countries during the second half of the twentieth century after the golden age of mass production. The third wave is now ongoing with the IDs and the new industries of the beginning of the twenty-first century».

The wave of globalization during the nineties has challenged the MID, which has evolved into a new modern ID (the so-called ID Mark 3), whose definition is still «in progress» (Bellandi, De Propris 2015). The knowledge inputs generated within local business networks and the cognitive process are also affected by external relations (Bellandi *et al.*, 2018, p. 1672). The «closed» industrial district became an «open» model of innovation (Chesbrough, 2003; 2006). To promote innovation the integration between external and internal knowledge is more important and more formalized than before (Dei Ottati, 2018). The external relationship with suppliers, competitors, clients and universities becomes essential to develop new products or new processes (Powell, Grodal 2005; Huggins, 2010). In the modern industrial district knowledge sharing is more complex, since cluster knowledge must be integrated with the new codified knowledge produced in the global market (Dei Ottati, 2018, pp. 261-262). In the beginning, globalization and delocalization involve more uncertainty and a weakening of social relations. On the other end, impersonal relations thrive, and knowledge begins to be more codified than tacit. At the same time, globalization determines a *knowledge lack* (Dei Ottati, 2018, p. 263) for some districts, due to the difficulty to know the new environment (Mistri, 2010). After globalization, the introduction of automation with a remote control of industrial processes (Industry 4.0) reduces the delocalization and even it fosters the reshoring of the economic activity (Corò, 2018). As compared to the other forms of ID, the modern ID – given the complexity of the production and organizational process and the role of transversal technologies – requires more cooperation among firms in different sectors (Chesbrough, 2003; Hossain *et al.*, 2016; Ramesh *et al.*, 2018; Iacobucci, Perugini 2018). The industrial institutions also play a key role in favoring cohesion between production and social systems and help the smallest firms to adjust to globalization (Dei Ottati, 2018).

The modern ID uses as knowledge-transmission channels those considered in the traditional industrial district literature, in the knowledge-based literature (Camuffo, Grandinetti 2006; 2011; Maskell, 2001; Grandinetti, Tabacco 2003; Rullani, 2003) and in the open innovation literature (Chesbrough, 2003; 2006; Iacobucci, Perugini 2018).

Knowledge is processed in a complex way, and its transfer mechanisms include external and internal imitation, internal and external firm network, internal and external relationships with institutions, universities, associations, suppliers, customers and subcontractors, internal and external social networks, and face-to-face interactions as well as strong, occasional and weak ties.

In such a district, social networks stimulate transfers of information, knowledge and inputs that transform into new knowledge depending on the district's capabilities (Hervas-Oliver, Albors-Garrigos 2009; Ter Val, Boschma 2011). Within these networks, diffused knowledge and information are promoted by learning processes connected to the work, staff qualifications and

skills, investment in research and development (R&D), openness to technological cooperation, cooperation among workers and firms, the mobility of labor, collaboration and work culture.

Much of the relational or network analysis literature (e.g., Wasserman, Faust 1994; Powell, 1990; Giuliani, Bell 2005; Ter Wal, 2013) describes the dynamics of the connections among enterprises (unity) through the nodes and lines that connect them [4]. Knowledge networks facilitate the coordination and the integration of heterogeneous knowledge in contexts characterized by complexity, high uncertainty and numerous sources of knowledge. The ability to share tacit knowledge across all the nodes becomes one of the sources of competitive advantage for the district.

The diffusion of knowledge can be limited by constraints connected to the desire to transmit it (Witt *et al.*, 2007) and the ability to acquire it (absorptive capacity [5]) and then internalize it at both the organizational level (organization's absorptive capacity) (Choen, Levinthal 1989) and the individual level (individual's absorptive capacity) (Witt *et al.*, 2007).

In a global context, the absorption of knowledge becomes more complex, as combined district internal knowledge and external tacit and codified knowledge must be re-codified to adapt to the specific characteristics of the firms, which in turn become knowledge carriers through, for example, workers, suppliers and customers. Numerous studies have highlighted that innovation is not the by-product of an exogenous knowledge change but emerges from endogenous learning processes taking place within particular production systems organized in time and space (Jeannerat, Kebir 2013, p. 6).

Local institutions, associations, universities and research centers play a significant role in creating relationships between external and internal actors. At the same time, they can pursue policies aimed at supporing the district's enterprises, innovation and internationalization.

Empirical analysis provides evidence that the channels of knowledge transfer examined above are important for knowledge creation and are determinant factors in innovation (Camuffo, Grandinetti 2006; 2011; Becheikh *et al.*, 2006; Perkmann, Walsh 2007).

[4] This literature not only allows a representation of the network and the different types of relationships inside or outside that network at the national and/or international level, but it involves a quantitative and qualitative analysis of parameters such as the node and number of connections, the object of the relationships, the nature of the relationships, the network characteristics and the network typology.

[5] A firm's absorptive capacity consists of «the ability to sign the value of new, assimilate it, and apply it to commercial ends» (Choen, Levinthal 1989, p. 128). It depends on the absorptive capacity «[...] of its individual members» (Choen, Levinthal 1989, p. 131), as this «[...] allows them to acquire communicated or accessed knowledge and to exploit it without destroying it [...]» (Witt *et al.*, 2007, p. 11).

Thus, we propose a new operational model that aims to integrate the well-established knowledge-based literature and the open-innovation literature with the so-called «knowledge spiral» introduced by Nonaka and Takeuchi (1995) (Section 2). To this end, we apply our model to a case study based on the Apulia Fashion district. The empirical analysis (Section 3) is articulated in two steps. First, we operationalize the dimensions identified in the theoretical framework. Second, we estimate a multi-stage econometric model. Section 4 provides some concluding remarks.

2. A NEW «INNOVATION MIX» MODEL FOR MODERN INDUSTRIAL DISTRICTS

The Nonaka and Takeuchi model (NTM) (1995) considers a company in which knowledge is created through a constant exchange between its tacit and explicit dimensions according to a spiraling process, which in turns creates innovation. This «knowledge spiral» through the so-called «four modes of knowledge conversion» turns the know-how from the individual to the inter-organizational level. Below we will briefly review the aforementioned four modes are:

Socialization involves the sharing of tacit knowledge through interactions, ties, the diffusion of experiences, and mental models, and leads to the creation of new perspectives. Social networks play an essential role in this sharing. The keys to acquiring tacit knowledge are experience, observation, imitation and practice; in a firm, these happen through job training (Nonaka, Takeuchi 1995, p. 63), informal meetings, worker mobility, and interactions with suppliers and customers before and after product development.

Externalization turns tacit into explicit knowledge. It is generated particularly by dialogue, through which a new concept is expressed. A new product concept can be formed through socialization and externalization. In this connection, observation for imitation (Camuffo, Grandinetti 2006; Mistri, 2010) plays an essential role.

Combination transforms conceptual knowledge into systemic knowledge (explicit knowledge), which provides leaflets, meetings, and prototypes as deliverables. Systemic knowledge involves people interacting and combining knowledge.

Internalization is associated with «learning by doing», in other words, internalizing experiences into tacit knowledge held by individuals. Conference participation and learning at conferences and R&D play an important role in learning (Cohen, Levinthal 1989). This phase uses the concepts to produce something tangible such as a prototype – a new product or an innovation – embodying new corporate values, a new managerial system, or a new organizational structure. This tangible item is built by combining new explicit knowledge with existing knowledge. Documents, manuals and oral stories (tradition for Polanyi, 1962b) can help this mode.

Notwithstanding its articulation, the NTM presents some limits [6]. The major problem in applying a company-focused theory to clusters lies in the necessity of considering the diverse relations among firms which can have different interests. The knowledge that firms hold might be different or characterized by different degrees of tacitness, from the lowest degree to the highest. The innovations they generate could be of different types, varying in complexity. Nonaka and Takeuchi did not consider interactions with institutions and associations, which play an important role in bridging the internal and external environment, as we have evidenced in the theoretical section.

In addition, the NTM appears to be a closed, rather than open model, as it ignores the importance of organizational and individual absorptive capabilities, although outside knowledge depends on both. This issue deserves further investigation, but this analysis is beyond the scope of our paper.

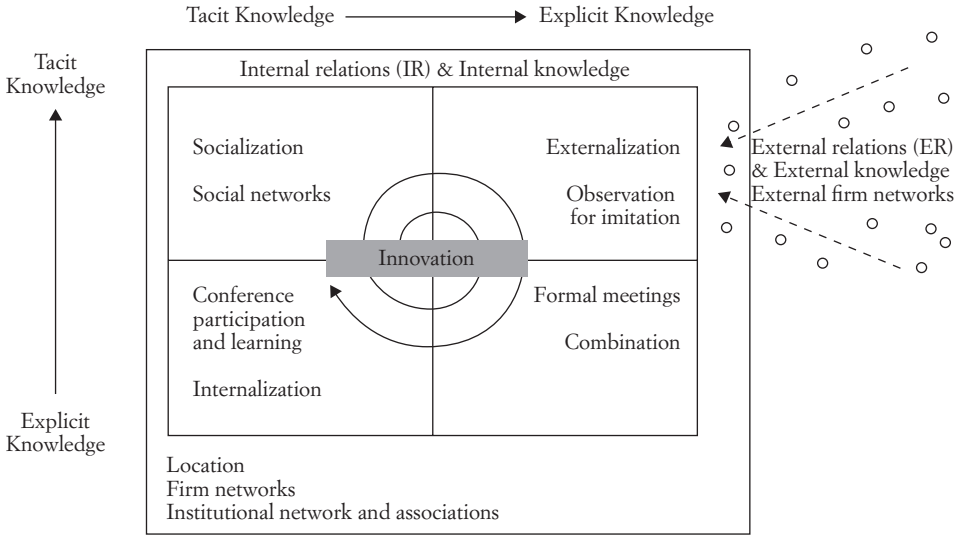
Gourlay (2006) also observes that the spiral of knowledge creation is a theoretical solution and that it does not support many case studies. A range of contributors have successfully employed the NTM model with Japanese companies (Nonaka, Takeuchi 2004) or with virtual learning (Hosseini, 2011). Nevertheless, its application to western companies or small organizations (e.g., Smits, de Moor 2004) uncovers its weak empirical base (Gourlay, 2006).

In summary, the NTM is based on the creation and diffusion of knowledge in an economic organization (Bratianu, 2010) realized through the continuous interaction between tacit knowledge and codification in a company. Their perspective is particularly suitable for explaining how tacit knowledge is transferred and how innovation occurs in an ID. In an ID, tacit knowledge spreads more easily via face-to-face interactions, strong and weak ties, informal meetings, high worker mobility and the imitation of innovation.

Once the model is opportunely integrated with the aforementioned channels of knowledge diffusion identified by knowledge-based theory and by open innovation literature (see p. 5), we believe that NTM weaknesses can be overcome. With this integration, one can explain how new knowledge originating outside the district spreads internally through the organization and is translated into new knowledge, innovation and products that are transmitted back to the outside. Although the NTM refers to a single firm and what occurs inside, it is applicable to the ID as a large dispersed enterprise (Brusco, 1991), within which knowledge is created through a complex interactive process between external and internal workers, managers, suppliers and buyers. In spite these changes, its application to third generation IDs requires that some other limits be overcome.

[6] See, among others, Adler (1995); Essers and Schreinemakers (1997); Jorna (1998); Szulanski (1996; 2000); Bereiter (2002); Szulanski and Jensen (2004); Bratianu (2010); Gourlay (2006).

FIG. 1. *The «spiral of knowledge relations» at work in an ID*



Source: own elaboration on NTM (1995), Camuffo and Grandinetti (2006; 2011) and open innovation literature (Chesbrough, 2003; 2006).

It is also important to add internal and external firm networks – which NTM does not consider – such as strong, weak or occasional ties with suppliers, buyers and customers.

Outside the district and at the international level, furthermore, knowledge conversion, creation and diffusion are more of an «organized process» involving contractual relations among firms (Belussi, Sedita 2012, p. 169). Firms have the capacity to catch external knowledge and to combine it with internal information (von Tunzelmann, Wang 2003; 2007).

Figure 1 is intended to represent the conceptual model that results from grafting the NTM onto the features of the knowledge-based theory and open innovation literature.

In our model, as in NTM, innovation (INN) is at the core of the «spiral of knowledge relations», and it is defined according to the Schumpeterian classification (Schumpeter, 1971; 1977).

It includes product innovation, process innovation, new marketing strategies, organizational innovation. We also recognize the importance of the design activity (Utterback *et al.*, 2006) since the specific case study considered. In this definition, we include computer-aided design/manufacturing (CAD/CAM).

Then, we consider the inter-organizational structures of the district – differentiated into internal relations (IR), external relations (ER) and internal-external relations (IER) – and the existence of district networks. These networks

also represent knowledge conversion, creation and diffusion inside and outside the district.

To identify the IR, we combine the NTM's four modes of knowledge conversion with the channels of knowledge diffusion recognized by ID theory and working through the spatial dimensions (location), the internal firm networks, the institutional network and associations. As we have noted, a new product concept can be formed through socialization and externalization, which are necessary if individuals' tacit and explicit knowledge are to be shared. Social networks play an essential role because socialization, as well as observation for imitation, are essential for externalization. Combination transfers a concept into systemic information through formal meetings, whereas internalization converts it into new tacit knowledge, i.e., conceptual models or technical know-how. Conference participation and learning help this conversion. Innovation is derived particularly from combination and internalization. The illustrated mix of the NTM, open innovation literature and ID theories explains how new knowledge that originates externally is shared within the district, stored in its knowledge base and utilized internally to develop new knowledge, innovations and products before being shared outside again through ERs. The External Relations involve the conversion, creation and diffusion of external knowledge through internationalization or over external firm networks.

As the ability of firms to search out and develop their knowledge is influenced by the size of the firm, its experience, its location, and research activities along with the aforementioned dimensions, we consider also the expenditure on R&D and design (RDD) by district firms and their structural features. The former represents the commitment to innovation (innovative effort) (INNINP) (OECD, 2002; Malerba, 2005) and captures firms' absorptive capacity (Cohen, Levinthal 1989; Aghion, Jaravel 2015). The size of firms (SIZE) and their experience (AGE), on the other hand, influence their ability to search and develop their knowledge. Both dimensions incorporate specific Marshallian characteristics and together with innovative effort influence the choice of relations and, consequently, innovation performance.

Table 1 presents a synthetic review of the discussion so far, combining the variables, their respective theoretical dimensions and their foundation in the literature.

3. EMPIRICAL ANALYSIS

3.1. *Methodology design*

As already stated, the objective of this study is twofold: investigating how knowledge is transferred in modern IDs and evaluating whether innovation

TAB. 1. *Key concepts, dimensions and their measurement*

Variable	Dimension	Description	Activity/Source
Innovation (INN)	Knowledge spiral	It is the continuous interaction between tacit and explicit knowledge in which the four modes interact in the process of product development (innovation)	Product innovation, process innovation, organizational innovation, new marketing strategies and CAD/CAM use (Schumpeter, 1971; 1977; Utterback *et al.*, 2006)
Internal relations (IR)	Socialization	It is the sharing of tacit knowledge. Social networks play an essential role	Social networks (Camuffo, Grandinetti 2006; 2011; Grandinetti, Tabacco, 2003; Rullani, 2003; NTM, 1995; Dei Ottati, 2018)
	Externalization	It leads to a new product concept. Observation for imitation plays an essential role	Observation for imitation (Camuffo, Grandinetti, 2006; 2011; Mistri, 2010)
	Combination	It transforms a concept into systemic knowledge	Formal meetings (NTM, 1995)
	Internalization	It converts explicit knowledge into new tacit knowledge, i.e., conceptual models or technical know-how	Conference participation and learning (NTM, 1995)
	Location	It is the concentration /dispersion of the district firms	Geographical space (Becattini, 2000)
	Internal firm networks	They facilitate and favor the conversion, creation and diffusion of knowledge	Internal firm networks (Camuffo, Grandinetti 2006; 2011; Maskell, 2001; Grandinetti, Tabacco, 2003)
	Institutional networks and associations	They play an important role bridging the internal and external environment	Institutional networks (Camuffo, Grandinetti, 2006; 2011)
External relations (ER)	External firm networks and external knowledge	They involve the conversion, creation and diffusion of external knowledge	Internationalization or trade relations (Camuffo, Grandinetti, Maskell 2001; Chesbrough, 2003; 2006)
Innovative input (INNINP)	Research activity	It includes R&D and design	R&D, design (OECD, 2002; Malerba, 2005; Utterback *et al.*, 2006; Aghion, Jaravel 2015)
Structural features (SF)	Size	It is the firm's size	Size (Becattini, 2000)
	Experience	It is the firm's age	Age (Becattini, 2000)

Source: own elaborations.

occurs through these mechanisms of knowledge conversion, creation and diffusion.

To this end, we suggest organizing the analysis in two steps. First, it is necessary to operationalize the conceptual model proposed in the previous section (see Table 1). This means «transforming» the different dimensions into measurable variables. In the second step of the investigation, a multi-stage econometric model must be considered. It must be based on a system of simultaneous equations spanning across 1) the influence of firms' relational choices (IR, ER, IER) on district innovative performance and 2) the influence of district firms' innovative effort and structural characteristics (age and size) on their relational choices.

For the empirical analysis, following Brusco (1991), we consider the ID as a single company. To calculate firms' relational choices, data can be derived by administering a questionnaire to each district firm. Once responses are reduced to the corresponding variables (see Table 2), they are normalized using the «min-max» method (Nardò *et al.*, 2005) as follows (equation 1):

$$I^t_{qf} = \frac{X^t_{qf} - \min_f(x^t_q)}{\max_f(x^t_q) - \min_f(x^t_q)} \tag{1}$$

where I^t_{qf} is the normalized variable at time t, q_f is the firm number; x^t_{qf} is the considered activity (item); and $\min(x^t_q)$ and $\max(x^t_q)$ are the minimum and the maximum values of across all f at time t. In this way, the normalized indicator has values between 0 (laggard $X^t_{qf} = \min_f(x^t_q)$) and 1 (leader $X^t_{qf} = \max_f(x^t_q)$). The sum of the responses must be evaluated according to a multi-item scale (Likert, 1932). To obtain a discrete scale reliability coefficient (Cronbach, 1951), the number of items within each variable might be outnumbered by those included in Table 2.

Given the multiple dimension to be considered at once, we apply the methodology of composite indicators (OCSE, 2008). The literature provides a wide range of aggregation methods. In our approach the values for each subdimension is recalculated in relation to the average and given equal weights.

To calculate the innovation (INN) of each district firm i in period t, we consider five items, i.e., product innovation, process innovation, organizational innovation, new marketing strategies and CAD/CAM use.

The IR are calculated according to four items: social networks (SN), geographical space (GS), internal firm networks (IFN) and institutional networks (IN). The SN include ties, workers' mobility, observation for imitation, formal meetings and conference participation.

The ER variable contains a single item: external firm networks (EFN).

The IER encompass the former two dimensions: IR and ER

Table 2 summarizes how each variable is measured. In it, for the sake of completeness, we also include the innovative input and the structural features for each district firm. R&D and design expenditure (INNINP) is measured by considering the natural logarithm of expenditure in R&D and design/ labour number of district firms in the considered year, whereas firms' age (AGE) measures the years of experience of district firm i in period t. To measure it, we have normalized the year variables. Finally, the firm size (SIZE) variable is calculated with natural logarithm of the number of workers in each district firms during the considered year.

As noted earlier, the conceptual problem we face is identifying the influence exerted by the characteristics of the district firms on the choice of interorganizational structures and, at a second stage, the effect of this on innova-

TAB. 2. *Key concepts, dimensions and their measurement*

Variable	Item	Activity	Measure
		District inter-organizational structures	
Innovation (INN) *5 items*	Product innovation, Process innovation, Organizational innovation New marketing strategies CAD/CAM use		New products New processes, New organization, CAD/CAM use (1 = if yes; 0 = if no)
Internal relations (IR) *4 items*	Social networks (SN)	Social networks	Face-to-face relations (from 1 = not important to 5 = very important); number of informal meetings in a month (from 0 to 5 meetings/relations in a month), workers' mobility (from 1 = not important to 5 = very important)
		Observation for imitation	Number of participants in trade fairs; articles in industry magazines (from 1 = not important to 5 = very important)
		Formal meetings	Number of formal meetings in a month (from 0 to 5 meetings/relations in a month)
		Conference participation and learning	Number of conference participants
	Geographical space (GS)	Geographical space	$\min(x_q^t) = 1$ if the firm is in the center of the district, and $X_{qf}^t = z$ km from the center, where z is the distance from the center in kilometers
	Internal firm networks (IFN)	Internal firm networks	Vertical and horizontal integration with other firms localized in the district, number of subcontracting firms (from 1 = not important to 5 = very important)
	Institutional networks (IN)	Institutional networks	Relationship between firm and institutions and between firm and associations (from 1 = not important to 5 = very important)
External relations (ER) *Single item*	External firm networks (EFN)	Internationalization or External firm networks	Vertical and horizontal relationships with firms localized outside Italy and district (from 1 = not important to 5 = very important)
Internal and external relations (IER) *2 items*	Internal relations (IR) External relations (ER)		
		Additional variables	
Innovative input (INNINP)	R&D, design		Natural logarithm of expenditure on R&D and design/labour number in the district firms
Structural features	Size		Natural logarithm of number of workers in the district firms
	Age		Years of experience of the district firms

Source: own elaborations.

tion performance. Thus, it is necessary to model these two different relations at the same time.

The econometric literature (Baron, Kenney 1986; Heckman, 1979) has proposed different classes of models to cope with similar problems. We suggest solving the endogeneity problem by running a two-stage model to obtain undistorted and efficient estimates. Therefore, we estimate two equations.

The first equation aims to determine the probability that the ID's relational choices (DISTR_REL) influence its innovative performance (INN) (equation 2):

$$(2) \qquad \text{INN}_{i,t} = \alpha_0 + \alpha_1 \text{ DISTR\_REL}_i \text{ (IR; ER; IER)} + \varepsilon_t$$

where innovation (INN) is a binary variable taking the value of one when a district enterprise innovates and zero when it does not.

The second equation (3) instead focuses on how the relational choice is influenced by the characteristics of the district firms (SIZE and AGE) and by the commitment to innovation (INNINP).

$$(3) \qquad \text{DISTR\_REL}_{i,t} = \beta_0 + \beta_1 \text{AGE}_{\text{i,t}} + \beta_2 \text{SIZE}_{\text{i,t}} + \beta_3 \text{INNINP}_{i,t} + \varepsilon_t$$

As it is a two-step approach, we first run equation (3) to determine the values of DISTR_REL and then equation (2) to estimate the impact on innovation performance (INN).

The next section presents the results obtained applying the proposed methodology to a specific case study: the Apulian fashion district.

3.2. *Analysis and results*

3.2.1. *The sample: The Apulian fashion district*

Our analysis is conducted on the Apulian Clothing Industrial District for the year 2012. This ID was formally acknowledged in 2010 [7]. It includes firms specialized in the production of clothing for men, women and children and firms specialized in the production of ceremonial wedding dress. We use the Infoimprese database of Bari's Chamber of Commerce in order to build our firms' sample. From this database composed by 177 firms; 72 given effective responses to the questionnaire. Of these, 20.8 per cent are small firms with between 10 and 19 employees. The sample also includes many micro-enterprises (37.5 per cent). By contrast, there are fewer medium-sized companies (27.8 per cent) or relatively large ones (13.9 per cent), although

[7] See the Regional Law n. 23/2007.

TAB. 3. *Observations by firm size and characteristics*

Firm Size	Number	%	Characteristics					
			Employees		R&D, D per employee €	Marketing expenditure per employee €	Product innovation %	Process innovation %
			Number	%				
Micro (up to 9 employees)	27	37.5	79	4.7	835.4	778.4	21.2	31.3
Small (between 10 and 19 employees)	15	20.8	178	10.6	2626.4	2059.2	18.3	30.1
Medium (between 20 and 49 employees)	20	27.8	564	33.5	1670.2	1799.6	25.5	22.9
Relatively Large (between 50 and 250 employees)	10	13.9	861	51.2	998.8	836.2	35.0	15.7
Total sample	72	100	1682	100.0	1425.4	1299.7	100	100

Source: own elaborations.

these have a greater weight in terms of the number of employees. In fact, larger companies provide little more than 50 per cent of the jobs in the selected sample, and another 33.5 per cent are attributable to medium-sized companies. Therefore, companies with fewer than 19 employees (micro-enterprises and small businesses), although numerically prevalent, employ less than a quarter of the sample's workers (Table 3).

Comparing the firm size with the level of innovation, we note that the percentage of innovative firms is high, in terms of both product innovation and process innovation. This tendency increases in accordance with firm size for product innovation, but this tendency is not confirmed for process innovation, probably because, in this case, machinery is a substitute for manual work. Expenditure in R&D and design and expenditure in marketing per employee is high, but it is not dependent on firm size. We note that firms with a size between 10-19 or 20-49 employees spend more per employee (Table 3).

In order to consider the year of the firms' foundation, it should be noted that 33.3 per cent of the enterprises commenced their activity between 1980 and 1989, 23.6 per cent between 1990-1999, and only 16.6 per cent after 2000. All others (26.6 per cent) started before 1979. This means that just few firms are young, whereas 8.3 per cent are very old.

To gather the above information, we chose a multi-method approach, administering the questionnaire by phone, by e-mail, by appointment and during trade events, as they constitute temporary clusters (Maskell *et al.*, 2006).

Our original questionnaire, along with the characteristics of the district firms, allowed us to develop qualitative and quantitative indicators for studying *a*) the mechanisms for converting, creating and diffusing knowledge into

the district; *b*) the internationalization of the district and *c*) the measurement of innovation. The results are presented and commented upon in the following paragraphs.

3.2.2. *District inter-organizational structures*

Consistent with the theoretical framework presented in Section 2, the questionnaire was structured to collect relational information regarding knowledge exchange and collaboration activity. We have focused our attention on the firms having a technical-productive relationship (exchange of raw materials, semi-finished products or finished products) or a strategic relationship (joint technology development, new products and agreements in the marketing area). Despite our interest in the so-called direct links of the enterprises, the survey allowed us to highlight the connections between different structures and to focus on different pivotal enterprises.

Different kinds of relationships – formal and informal meetings with suppliers, customers, stylists and institutions as well as membership in trade associations or attendance at trade fairs – were all considered in both their internal and external dimensions.

To test the conceptual model, this study adopts 10 items divided as follow: innovation with 5 items, internal relations with 2 items; external relations with 1 item and internal and external relations with 2 items. Table 4 displays the resulting operationalization of the dimensions into the measures reported in Table 2. All of the variables show a satisfactory reliability coefficient (Cronbach's alpha value) [8]. To ensure reliability, we had to reduce the IR items from 4 to 2 (SN and IFN).

The empirical outcomes portray the Apulian fashion district as capital intensive, technology intensive and marketing and demand driven. Following Pavitt's taxonomy (1984) and Peneder's tripartite classification (2001), it is possible to distinguish the fashion sector into three categories: classic, innovative and traditional/fashion. In the classic group (33.3 per cent of sample firms [9]), innovation is low, R&D and design are developed in-house, labor-intensive processes prevail, workers have high, specific skills and learning by doing is crucial. Outdoor garments [10] fall in the innovative category (54.2 per

[8] A «good» coefficient is arbitrary and depends on theoretical knowledge of the scale in question (Goforth, 2015).

[9] Production is mainly represented by ceremonial clothing and wedding dresses for women and underwear and dresses for men, women and children.

[10] Outdoor garments are sportswear such as tracksuits, jackets and outdoor wear for men, women and children.

TAB. 4. *District inter-organizational structures*

Variables	Dimension	Cronbach's alpha
Innovation (INN)	5 items: Product innovation Process innovation Organizational innovation CAD/CAM use New marketing strategies	0.53
Internal relations (IR)	2 items: Social networks (SN) Internal firm networks (IFN)	0.39
External relations (ER)	1 item: External firm networks (EFN)	
Internal and external relations (IER)	2 items: Internal relations (IR) External relations (ER)	0.66

Source: own elaborations.

cent of the sample). In this case, innovation is high, R&D and design is conducted in-house, technology-intensive processes prevail, and workers have high and generic skills. We include knitted goods in the traditional/fashion category (12.5 per cent of the firms [11]), where marketing and investment in design are very important, processes are fashion-intensive, and medium-skill white-collar workers represent the majority of employees.

Production is organized according to two global supply chains. The first supply chain uses Italian and European suppliers to produce a complex product of high quality, while the second one uses Asian suppliers to produce more standard pieces.

Institutions do not play an important role. They do not sufficiently support or finance firms wishing to participate, nor do they organize events or exhibitions. Most of the district firms, by contrast, are sustained by trade associations, which play a strategic role by allowing entrepreneurs to meet, exchange ideas, and organize events.

3.2.3. *District innovation performance*

In assessing whether firms' relational choices (IR, ER, IER) influence district innovative performance, as stated above, we conduct our analysis in two steps. First, we estimate equation [3] to gauge the impact that firms' characteristics (INNINP, AGE, and SIZE) have on the district relational structures. Then, we run equation [2] to assess whether the latter affect district innovation. We employ

[11] The goods include pullovers (cotton, woolen and cashmere pullovers), casual clothing and hosiery.

TAB. 5. *Descriptive statistics*

Variable	Observations	Mean	Std. Dev.	Min.	Max
INNOVATION (INN)	72	0.665	0.474	0	1
INTER. REL (IR)	72	0.457	0.197	0	0.96
EXTER. REL. (ER)	72	0.690	0.376	0	1
INT. EXT. REL (IER)	72	0.575	0.229	0	0.98
INNINP	72	4.722	3.542	0	11
AGE	72	0.356	0.250	0	1
SIZE	72	2.408	1.388	0	5.01

Source: own elaborations.

a multinomial probit model as our dependent variable; innovation (INN) is a dummy that takes a value of one when an enterprise innovates, and zero when it does not. The key variables for our analyses are IR, ER, and IER.

Table 5 reports that 66 per cent of district firms demonstrate innovative performance, 57 per cent of companies have relationships that are internal and external to the district under consideration and 69 per cent have relations with at least one firm outside the district.

Table 6 indicates the baseline specifications set of Probit regressions estimating. The usual tests corroborate the credibility of our IV specification. In particular, Wald test of the exogeneity of the instrumented variables at the bottom of the output rejects the null hypothesis of no endogeneity.

The estimates presented confirm that the propensity to innovate in industrial districts is related to the knowledge dynamics entailed by their relational assets. The internal and external relations, in fact, are significantly and positively associated with district' innovation at 1 per cent and we note that an increase of internal and external knowledge relation equal to 1 per cent could lead to an increase of about 36 per cent of innovation. This finding is aligned with that emerging from the survey and in line with the literature (Corò, 2018); most of the enterprises in the sample, even the smallest ones, marginally innovate their products. Many use CAD/CAM programs, but few radically innovate or use new, innovative organizational marketing processes. Moreover, although all the variables are highly significant, IER presents a higher coefficient than IR and ER.

This higher coefficient for IER, i.e., joint internal-external knowledge, confirms our hypothesis regarding the presence of a «knowledge-spiral» at work within the district through a continuous exchange of tacit and codified knowledge inside and outside the district. Innovation emerges when firms, and particularly the younger and the larger firms, have the capacity to capture external knowledge and to combine it with their own or the district's internal know-how.

The understanding developed to this point appears to be confirmed by the absence of significance for all district characteristics for IR, suggesting that

atomistic, rather than cooperative, behavior prevails within the district. Probably, they are the smallest firms that such remember the literature (Dei Ottati, 2018) have not financial resources to access to external knowledge and at the same time they have not the capacity to absorb this knowledge.

Moreover, the estimates presented in Table 6 confirm, as expected, that firm characteristics and innovative effort influence the choice of district relations, which in turn determine the innovative performance of the district.

With regard to the firm dimension variable (SIZE), it is significant, and it positively influences the choice to relate to external environment. This result is in line with the literature which shows that in time of globalization the larger firms build a system of relations with the external world (Dei Ottati, 2018). Indeed, looking at the answers provided to the questionnaire, larger and medium-sized firms favor the exchange process, representing a bridge between the internal and external knowledge networks. These firms are the leaders of the network [12]. They build up a system of relationship and they might be considered as «stars» or leader firms of this innovation model (Lombardi, 2017; Chesbrough, Appleyard 2007). These firms are also very dynamic since they captured the knowledge and absorb it by other firms through the imitation process.

According to the literature, the significance of the INNINP variable suggests that despite the years of economic recession (the year of the survey is, in fact, 2012), these firms make an effort to be innovative and more internationally oriented in order to both gain new markets and/or reduce production costs, relocating phases of the production process to countries where the cost of labor is lower.

In contrast, the years of experience of the business district (AGE) is always negatively correlated with the different types of district relations and not significant. This confirms that in a global context, acquired skills lose their importance. Reading this outcome in the light of the survey, we affirm that the oldest firms in the district make little innovative effort in comparison with the youngest ones, and also unlike the youngest firms, they interact little or less with other Italian and foreign companies. The youngest firms were established in a highly competitive environment and therefore are more attentive to ERs while, at the same time, benefitting from the experience of older firms. These older firms, instead, are strongly linked to traditions.

As the literature has stressed the importance of the institutional governance (Dei Ottati, 2018) emphasizing the importance of a coordinated and coherent public policy enabling the districts to face the challenges imposed by the globalization, we decide to run the model including the institutional dimension

[12] Following Bagella and Pietrobelli (2000), in absence of turnover, we measure the leadership according to the trade relations, which can be considered as a proxy for the degree of internationalization.

(see columns (*c*), (*g*) and (*l*) in Table 6). The variable INST is derived following the same methodology previously described. It includes 3 items: contacts with the public institutions, participation in fairs and in trade associations. The choice to include the three dimension is driven by the already mentioned literature on institutional governance (Dei Ottati, 2018). As expected, it is significant in the case of the external relations and when the district is porous to the internal-external exchange. Given that institutions do not play an important role, and this outcome is mainly driven by the participation in trade associations, which facilitate entrepreneurs to meet, exchange ideas, and organize events. Our result emphasizes the need of that desired public policy necessary to support the reproduction of the industrial district over time (Dei Ottati, 2018).

3.2.4. *Alternative estimation and robustness check*

As robustness check, we constructed a different dimension for the External relations (ER) applying the definition of Open Innovation (OI). The process of open innovation can be defined as «a distributed innovation process based on purposively managed knowledge flows across organizational boundaries» (Chesbrough, Bogers 2014). Consequently, it can be also considered as a proxy for the knowledge dynamics determined by the degree of openness of the single firms and of the district. OI includes the frequency of attendance to industry conferences and of the formal or informal contacts with other foreign companies in the same sector. The index is constructed following the methodology applied to the other variables and ranges from 0 to 1. For the sake of completeness, we also introduce a new variable addressing the interaction between the Internal and External Relation labeled Internal relations and Open Innovation (IROI), where OI is included. Table 7 shows the findings obtained considering the two kinds of relations. In general, these results confirm the previous evidence. External knowledge is always positive and significant thus confirming the baseline results. This means that if knowledge exchange increases of 1 per cent, this could lead to a growth of about 33 per cent of innovation.

4. CONCLUDING REMARKS

The main purpose of this paper is to extend the stream of literature aiming to explain how knowledge is created and spread within an ID and how this process favors innovation.

To this end, we propose a new operational model on how firms' relational assets facilitate the knowledge dynamics. To test it, we consider a specific case study: the Apulian fashion district.

TAB. 6. *Estimation results*

DEP.VAR: Innovation (INN)	[1]				[2]				[3]			
	(*a*) *Coeff*	(*b*) *dy/dx*	(*c*) *Coeff.*	(*d*) *dy/dx*	(*e*) *Coeff.*	(*f*) *dy/dx*	(*g*) *Coeff.*	(*h*) *dy/dx*	(*i*) *Coeff.*	(*j*) *dy/dx*	(*l*) *Coeff.*	(*m*) *dy/dx*
IR	5.305***	0.276	5.305***	0.251								
	(0.462)	(0.662)	(0.461)	(0.779)								
ER					3.298***	0.182	3.292***	0.133				
					(0.415)	(0.140)	(0.411)	(0.127)				
IER									5.492***	0.356**	5.479***	0.288
									(0.641)	(0.066)	(0.644)	(0.200)
cons	–2.335***		–2.175***		–1.921***		–1.894 ***		–2.803***		–2.790***	
	(0.236)		(0.338)		(0.334)		(0.344)		(0.392)		(0.394)	
DEP.VAR: District Relations	[1] Internal relations (IR)				[2] External relations (ER)				[3] Internal and external relations (IER)			
	Coeff.	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*
ININP	0.00335	0.024**	0.00317	0.231**	0.0186**	0.017**	0.0155*	0.015*	0.0125**	0.019**	0.0108**	0.017**
	(0.00291)	(0.016)	(0.00265)	(0.185)	(0.00836)	(0.026)	(0.00799)	(0.008)	(0.00520)	(0.013)	(0.00499)	(0.008)
SIZE	0.0185	0.134***	0.0189	0.022***	0.146***	0.130***	0.141***	0.135***	0.0787***	0.118***	0.0767***	0.121***
	(0.0131)	(0.000)	(0.0123)	(0.010)	(0.0269)	(0.000)	(0.0249)	(0.026)	(0.0164)	(0.000)	(0.0153)	(0.025)
AGE	–0.0153	–0.111	–0.0232	0.136	–0.154	–0.137	–0.193*	–0.185	–0.0671	–0.101	–0.0916	–0.145
	(0.0244)	(0.513)	(0.0275)	(0.032)	(0.115)	(0.192)	(0.112)	(0.112)	(0.0714)	(0.356)	(0.0706)	(0.116)
INST			0.0353	–0.171			0.302**	0.288			0.176**	0.278
			(0.0324)	(0.184)			(0.120)	(0.120)			(0.0749)	(0.121)
cons	0.403***		0.389***		0.307***		0.210**		0.352***		0.293***	
	(0.0465)		(0.0519)		(0.0763)		(0.0862)		(0.0491)		(0.0558)	
Obs.	72		72		72		72		72		72	
R^2	0.50		0.52		0.40		0.29		0.34		0.30	
Log likelihood	–9.900935		–8.7371982		–38.887004		–35.762295		–5.7280233		–2.9241498	
Wald test of exogeneity	$\chi2(1) = 12.83$ $p = 0.0003$		$\chi2(1) = 9.25$ $p = 0.0003$		$\chi2(1) = 18.54$ $p = 0.0000$		$\chi2(1) = 19.83$ $p = 0.000$		$\chi2(1) = 19.01$ $p = 0.0000$		$\chi2(1) = 19.78$ $p = 0.0000$	

Note: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The coefficient estimates are robust also using Newey's (1987) efficient two-step estimator. Results are available upon request.

TAB. 7. *Estimation results*

DEP.VAR: Innovation (INN)	[2]				[3]			
	Coeff.	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*
OI	4.516***	0.256	4.566***	0.164				
	(0.378)	(0.209)	(0.387)	(0.122)				
IROI					5.680***	0.336	5.718***	0.252
					(0.495)	(1.198)	(0.491)	(0.799)
cons	–1.749***		–1.732***		–2.347***		–2.337***	
	(0.197)		(0.192)		(0.230)		(0.234)	
DEP.VAR District Relations	[2] Open Innovation (OI)				[3] Internal relations and Open Innovation (IROI)			
	Coeff.	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*	*Coeff.*	*dy/dx*
ININP	0.000131	0.023	0.00156	0.023*	0.00164	0.024*	0.00244	0.023*
	(0.00109)	(0.022)	(0.00286)	(0.011)	(0.00243)	(0.011)	(0.00248)	(0.010)
SIZE	0.000846	0.146	0.00951	0.139*	0.00963	0.138*	0.0142	0.134*
	(0.00696)	(0.120)	(0.0154)	(0.037)	(0.0123)	(0.034)	(0.0114)	(0.033)
AGE	–0.000755	–0.130	–0.0127	–0.186	–0.00880	–0.126	–0.0188	–0.178
	(0.00631)	(0.204)	(0.0254)	(0.191)	(0.0160)	(0.172)	(0.0240)	(0.184)
INST			0.0167	0.244			0.0272	0.257
			(0.0352)	(0.207)			(0.0323)	(0.180)
cons	0.386***		0.355***		0.352***		0.371***	
	(0.0382)		(0.0628)		(0.0491)		(0.0496)	
Obs.	72		72		72		72	
R^2	0.20		0.20		0.45		0.45	
Log likelihood	–19.475901		–35.762295		–4.0589289		–2.9977189	
Wald test of exogeneity	$\chi2(1) = 18.54$		$\chi2(1) = 4.34$		$\chi2(1) = 6.07$		$\chi2(1) = 10.92$	
	$p = 0.0047$		$p = 0.0372$		$p = 0.0137$		$p = 0.0010$	

Note: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The coefficient estimates are robust also using Newey's (1987) efficient two-step estimator. Results are available upon request.

The empirical results support our hypothesis regarding the presence of a «knowledge relations -spiral» at work within the district through the continuous exchange of tacit and codified knowledge inside and outside the district. The results outline that innovative performance depends above all on the combinations of IER that district firms choose or are able to establish. This result is in line with the considered literature which shows that in time of globalization the larger firms build a system of relations with the external world (Dei Ottati, 2018). It also stresses the weakness of the institutional governance. Institutions do not sufficiently support or finance firms wishing to participate, nor do they organize events or exhibitions. Most of the district firms, by contrast, are sustained by trade associations, which play a strategic role.

Thus, innovation is indirectly influenced by the characteristics of the district and by firms' innovative effort. Younger and/or leading firms focus more externally, but they also show the capacity to grasp the know-how already present inside the district. This attitude means that they can be considered to be a strategic resource to reduce inertia within the district by capturing, absorbing and changing external knowledge and promoting it within the district and across all firms.

In a global context, innovation is more complex than in a traditional context because it completely modifies the firm's organization and relations (Storper, 2009). Although the definition of the new modern ID is still «in progress» (Bellandi, De Propris 2015), nonetheless, what is clear is that it requires the addition of other channels of knowledge spillover and creation such as those considered in our analysis. Moreover, the results regarding the institutional aspect provide a useful insight in terms of policy. As it was observed «institutions [...] are called upon to promote policies capable of assuring coherence between the evolution of the economic and the social system: only thus can the synergic relation between competition and cooperation be reproduced. This relation is necessary for the vitality of the district» (Dei Ottati, 2018, p. 279). Specifically, local institutions should be able to involve and help even the smallest companies to open up to the market and be involved in the innovative process.

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