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Proximity and Distance in Knowledge Relationships: From Micro to Structural Considerations based on Territorial Knowledge Dynamics (TKDs)

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CRESPO J. and VICENTE J. Proximity and distance in knowledge relationships: from micro to structural considerations based on territorial knowledge dynamics (TKDs), *Regional Studies*. Among the key parameters identified in territorial knowledge dynamics (TKDs), this paper focuses on the balance and trade-off between proximity and distant relations, especially as far as knowledge relationships are concerned. This entry is investigated through an original process consisting in combining micro-motives for knowledge relationships and structural properties of resulting knowledge networks, always paying attention to the balance between proximity and distance. From the information available in EUODITE case studies and the presentation of the methodology, the micro-foundations of proximity and distance in knowledge relationships are explored according to the knowledge trade-off and the complex knowledge value chain that typify the modern knowledge process. Based on these micro-considerations, a structural analysis of TKDs is inferred that provides significant patterns of their structuring. From these patterns policy implications are extracted which show that collaborative incentives on some particular missing links fit better with effective policies than the common view of ‘connecting people’ policies.

Territorial knowledge dynamics EUODITE Knowledge trade-off Knowledge value chain Structural analysis
Regional policy

CRESPO J. and VICENTE J. 知识关系中的邻近性与距离：根据领域知识动态 (TKDs)，从微观到结构的考量，区域研究。本文在领域知识动态 (TKDs) 中所指认的主要参数之中，聚焦邻近性与距离关系之间的平衡与权衡交换，并特别考量知识的关系。此一进入方式，透过包含结合知识关系的微观动机与所产生的知识网络的结构特征的独创过程进行探讨，并永远关注邻近性与距离之间的平衡。从EUODITE案例研究中可取得的信息，以及方法论的呈现，本研究根据代表现代知识过程的知识权衡交换以及复杂的知识价值链，探讨知识关系中的邻近性与距离的微观基础。根据这些微观考量，本文推断出TKDs的结构分析，该分析提供了其结构化的重要模式。政策意涵从这些模式中萃取，展现出在部分特定欠缺的连结上的合作奖励，较一般认为的“连结人们”的政策更符合有效的政策。

领土知识动态 EUODITE 知识权衡交换 知识价值链 结构分析 区域政策

CRESPO J. et VICENTE J. La proximité et la distance dans les relations fondées sur le savoir: des considérations microéconomiques vers des considérations structurelles basées sur la dynamique des connaissances territoriales, *Regional Studies*. Parmi les paramètres clés relevés dans la dynamique des connaissances territoriales (territorial knowledge dynamics; TKD), ce présent article se concentre sur l'équilibre et le compromis entre la proximité et la distance géographiques, surtout pour ce qui est des relations fondées sur le savoir. On propose d'examiner cette entrée par moyen d'une approche originale qui allie les motifs micro-économiques des relations fondées sur le savoir et les propriétés structurelles des réseaux de connaissances qui en découlent, prêtant une attention particulière à l'équilibre entre la proximité et la distance. À partir des études empiriques EUODITE et d'une présentation de la méthodologie, on explore les bases microéconomiques de la proximité et de la distance dans les relations fondées sur le savoir selon le compromis du savoir et la complexité de la chaîne de valeur qui caractérisent le processus d'innovation moderne. À la lumière de ces considérations micro-économiques, on fait une analyse structurelle des TKD qui fournit d'importantes tendances quant à leur structuration. On en déduit des implications pour les politiques publiques montrant que les incitations aux relations fondées sur le savoir en ce qui concerne

certain liens manquants correspondent mieux aux politiques efficaces que le point de vue universel des politiques qui envisage de ‘relier la population’.

Dynamique des connaissances territoriales EURODITE Compromis du savoir Chaîne de valeur de la connaissance
Analyse structurelle Politique régionale

CRESPO J. und VICENTE J. Nähe und Distanz in Wissensbeziehungen: von Mikro- zu strukturellen Aspekten auf der Grundlage der territorialen Wissensdynamik, *Regional Studies*. In diesem Beitrag konzentrieren wir uns auf einen der wichtigsten identifizierten Parameter der territorialen Wissensdynamik, nämlich das Gleichgewicht und die Abstimmung zwischen Nah- und Fernbeziehungen insbesondere im Bereich der Wissensbeziehungen. Für die Untersuchung kommt ein Originalprozess zum Einsatz, der aus einer Kombination von Mikromotiven für Wissensbeziehungen mit den strukturellen Merkmalen der resultierenden Wissensnetzwerke besteht, wobei stets auf das Gleichgewicht zwischen Nähe und Distanz geachtet wird. Aufbauend auf den Informationen von EURODITE-Fallstudien und der Präsentation der Methodologie untersuchen wir die Mikrogrundlagen der Nähe und Distanz in Wissensbeziehungen in Übereinstimmung mit der Wissensabstimmung und der komplexen Wissens-Wertschöpfungskette, die für einen modernen Wissensprozess typisch ist. Anhand dieser Mikroaspekte wird eine strukturelle Analyse der territorialen Wissensdynamik abgeleitet, die signifikante Muster ihrer Strukturierung liefert. Aus diesen Mustern werden politische Auswirkungen extrahiert, die verdeutlichen, dass Anreize zur Zusammenarbeit hinsichtlich bestimmter fehlender Bindeglieder besser zu effektiven Politiken passen als die gängige Auffassung der Politiken für ‘Verbindungen zwischen Menschen’.

Territoriale Wissensdynamik EURODITE Wissensabstimmung Wissens-Wertschöpfungskette Strukturelle Analyse
Regionalpolitik

CRESPO J. y VICENTE J. Proximidad y distancia en las relaciones de conocimiento: de consideraciones micro a estructurales basadas en las dinámicas territoriales de conocimiento, *Regional Studies*. En este artículo analizamos uno de los principales parámetros identificados en las dinámicas territoriales de conocimiento, es decir, el equilibrio y el intercambio entre las relaciones de proximidad y distancia, especialmente en lo que afecta a las relaciones de conocimiento. Estudiamos este aspecto mediante un proceso original que consiste en combinar los motivos micro para las relaciones de conocimiento y las propiedades estructurales de las redes de conocimiento resultantes, siempre prestando atención al equilibrio entre la proximidad y la distancia. Basándonos en información de estudios empíricos de EURODITE y una presentación de la metodología, estudiamos las bases micro de la proximidad y la distancia en las relaciones de conocimiento según el intercambio de conocimiento y la compleja cadena de valores de conocimientos que caracterizan el moderno proceso de conocimiento. A partir de estas consideraciones micro, sugerimos un análisis estructural de dinámicas territoriales de conocimiento que ofrece patrones importantes de su estructuración. De estos patrones, deducimos implicaciones políticas que muestran que los incentivos de colaboración en algunos vínculos ausentes determinados encajan mejor con políticas eficaces que la visión común de políticas para ‘crear conexiones entre las personas’.

Dinámicas territoriales de conocimiento EURODITE Intercambio de conocimiento Cadena de valores de conocimientos
Análisis estructural Política regional

JEL classifications: R12, R58

INTRODUCTION

Since the 1980s the introduction of a territorial dimension into the study of innovative processes has generated a vast array of concepts such as learning regions, regional innovation systems, innovative milieus, industrial districts or clusters. MOULAERT and SEKIA (2003) grouped them under the generic term territorial innovation models (TIMs). Local knowledge spillovers, face-to-face contacts, embeddedness in local networks, trust and cumulative local knowledge dynamics are the key and regular parameters that have led to this wide production of concepts and research in regional science, putting regions as the main relevant scale for the development of the knowledge society. Nevertheless a growing part of the literature has criticized the excessive emphasis and overestimate of the role of local interactions in the innovative success of particular places. As a matter of fact, following SHEARMUR (2011), ‘local face-to-face contact, knowledge spillovers

and “buzz” are only part of the story, and maybe a small part at that’ (p. 1239). Implicitly or explicitly, TIMs contain the assumption that knowledge flows take place more easily over shorter distances than over longer distances (McCANN, 2007), while many other researchers have clearly shown that in many cases depending on the industries, the phase of the technology life cycles of the very nature of knowledge flowing in networks, long distances and outward-looking interactions matter as much (BATHELT *et al.*, 2004; OWEN-SMITH and POWELL, 2004; FITJAR and RODRÍGUEZ-POSE, 2011; ØSTERGAARD and DALUM, 2011; VICENTE *et al.*, 2011; HUBER, 2012; BALLAND *et al.*, 2013).

The exploratory concept of territorial knowledge dynamics (TKDs) developed in the EURODITE Project (CREVOISIER and JEANNERAT, 2009) is consistent with this growing literature, and provides a very useful empirical means to capture new patterns of knowledge-based regional development. In a context

in which the development of information technologies and the increase of mobility reshape knowledge flows, knowledge dynamics exhibit multi-location and multi-scalar dynamics that offer a better understanding of how some particular places succeed in using new economics possibilities. Then the TKDs concept does not reject single-place analysis, but invites, by considering multi-location systems, one to expand the analysis to larger territorialities. This crucial aspect of TKDs allows moving beyond the 'global relationships' or 'from elsewhere' arguments that are generally used in TIMs-based analysis when distant relationships and global networks are introduced (BALLAND *et al.*, 2013).

Using the empirical material of the EURODITE Project composed by a large and coordinated set of regional case studies, this paper concentrates on the various structural properties of TKDs. It pays peculiar attention to how proximate and distant knowledge relationships can play together in different innovative contexts. To do so, it studies the multi-scalar property of TKDs by analysing the micro-motivations behind relational behaviours of organizations, and then aggregating them to highlight the various forms of structural organization of TKDs. At a structural level, it identifies geographical openness, knowledge phase domination and connectivity as critical dimensions affecting TKDs' functioning, and constructs three typologies of TKDs based on them. It uses these typologies to obtain interesting policy implications claiming to go from local 'connecting people' policies, based on an unconditional increase of local networks density, to more effective policies based on 'surgical interventions'.

The paper is organized as follows. The second section adopts a micro-level perspective. Using TKDs resulting from the aggregation of interactions between several actors, it focuses on the micro-motives behind the construction of relationships, partner selection and their features (attributes). The third section presents information on the EURODITE case studies. The fourth section adopts a macro-level perspective, i.e. it focuses on the structural level of analysis, in order to identify structural properties that reveal differences in the functioning of TKDs. From these patterns, the fifth section draws some policy implications about the importance of surgical collaborative incentives focused on particular missing links.

THEORETICAL BACKGROUND: MICRO-MOTIVES FOR PROXIMITY AND DISTANCE IN KNOWLEDGE RELATIONSHIPS AND STRUCTURAL PROPERTIES OF TKDs

Knowledge trade-off and micro-motives for geographically proximate and distant knowledge relationships

Organizations construct external relationships in order to access relevant complementary resources, information or markets. However, as TKDs are of concern,

knowledge is placed at the core of the analysis. Then, access to new knowledge to remain competitive and innovative is the force behind the construction of external ties. The current shift towards complex, combinatorial, cross-sector knowledge underlines this trend (MANNICHE, 2012). This is called the accessibility issue. However, the advantages of accessibility can be counterbalanced by the fact that external relationships are costly and risky (GULATI, 1995). On the one hand, construction and maintenance of external relationships needs time and money to search for, bargain and monitor partners. On the other hand, since external relationships carry knowledge flows in both directions, they also support the risk of unintended knowledge spillovers and opportunistic behaviour of partners. This is called the appropriability issue (ANTONELLI, 2006). Building knowledge ties will depend on the balance between benefits and costs/risks. Such balance can also be presented in terms of a knowledge trade-off between accessibility and appropriability: better accessibility conditions imply the acceptance of higher risks of under-appropriation. This knowledge trade-off is one of the most important decision parameters for relationship-building (AHUJA, 2000, STRAMBACH and KLEMENT, 2012).

However, the terms of this trade-off are not homogeneous and constant for all knowledge relations. The characteristics and nature of the relationships (partners involved and context of interaction) may affect the benefits, costs and risks, and so modify the terms of the trade-off. Under the admitted constraint that, *ceteris paribus*, risks and opportunities of knowledge spilling over between connected or unconnected neighbours are stronger with geographical proximity (AUDRETSCH and FELDMAN, 1996; IAMMARINO and MCCANN, 2006), organizations consequently manage their portfolio of partners in geographical proximity or distance. That is, if the perceived risk of unintended spillovers is high (low), relationships with geographically distant (close) partners will be privileged. But, which are the other factors that affect the perceived benefits, costs and risk of a relation?

Firstly, there is the nature of the partner. Different types of organizations (universities, start-ups, big firms, agencies etc.) react differently to the knowledge trade-off because they differ in the nature of the goals accepted as legitimate, their degree of knowledge disclosure and the features of the reward system (DASGUPTA and DAVID, 1994; OWEN-SMITH and POWELL, 2004). These differences modify their perception about the benefit of accessibility and the risk of under-appropriability. Public research organizations (PROs) are less concerned by the risk of under-appropriability. Beyond research and formation, the diffusion of knowledge (giving increased accessibility) has become the PROs' 'third mission', and their legitimacy and reputation depends on it. JAFFE *et al.* (1993) found that new knowledge flows out of universities much more readily than it

does from commercial organizations. But not all commercial organizations are alike. Incumbents and big firms are conditioned by their profit-seeking on the market. So, knowledge appropriability becomes a key issue for their competitiveness, market position and survival. They use the absorption of small innovative firms and the accumulation of patents as a source of market competitiveness to reinforce their success. Contrary, start-ups and spin-offs are more open than big firms to knowledge disclosure (AHUJA *et al.*, 2009). Due to their origin and commitment with intensive research and development (R&D) activities, start-ups and spin-offs are usually halfway between the world of science and the world of industry. They often act as bridges between cognitively distant organizations. Their small size reduces their organizational inertia and enhances their commitment in exploration and integration processes to find new spaces and opportunities ignored by larger firms more centred on market exploitation (ALMEIDA and KOGUT, 1997). Their patenting activity, rather than appropriability, seeks to signal partnership in order to overcome size constraints to reach the market (AHUJA *et al.*, 2009).

Secondly, the heterogeneous competences of organizations (NELSON and WINTER, 1982) affect the knowledge trade-off too. Profitable knowledge ties require a balance between novelty and comprehension, i.e. organizations need partners with different cognitive bases that bring novelty, but not too different to enhance mutual understanding. So, the terms of the trade-off will depend on the absorptive capacities of (COHEN and LEVINTHAL, 1990) and the cognitive gap *between* the organizations, their potential partners and the organizations located in their geographical neighbourhood (NOOTEBOOM, 2000). When their cognitive bases are close, the risk of unintended knowledge spillovers grows. The risk is stronger if the partners are geographically close, so they fit better with geographical distance and temporary proximity (TORRE, 2008). On the contrary, when the knowledge bases are distant, the risks of misunderstandings increase (NOOTEBOOM, 2000) and the benefits of accessibility decrease. In these cases, relations with geographically proximate actors are fitted to bridge the gap between the partners' knowledge bases. The lower costs of collaboration and the higher efficiency of face-to-face contacts (STORPER and VENABLES, 2004; MCCANN, 2007) enhance accessibility and keep appropriability under control.

However, interactions do not occur in a vacuum and the terms of the knowledge trade-off depend on the surrounding context. A first contextual factor is the phase of knowledge value chain in which the relationship is inscribed. COOKE (2005) and ASHEIM *et al.* (2007) distinguish three phases in the knowledge value chain through which the perception of risks and opportunities are not the same: (1) knowledge exploration, where fundamental research on technological feasibility is

run; (2) knowledge examination, where applied research on product development, standardization and integration is run; and (3) knowledge exploitation, consisting of knowledge activities of commercialization, diffusion and the search of scale economies. When shifting from exploration to exploitation, the proximity to the market increases. Consequently, the attitude towards knowledge disclosure changes, and the risk of unintended spillovers rises because knowledge codification increases (ANTONELLI, 2006), and because cognitive distances between organizations diminish (SUIRE and VICENTE, 2009; MENZEL and FORNAHL, 2010). These shifts increase appropriability concerns, and push towards long-distance knowledge ties as far as relationships reach the exploitation phases. However, there are several counterbalancing forces that nuance the pattern of 'local exploration and global exploitation'. The limits of the local availability of the required knowledge, and the belonging to a larger technological domain, play against the role of local knowledge relationships in exploration. Similarly, the need of cooperative strategies among co-located direct competitors, and the need of frequent meeting for design and consultancy, nuance the role of distant interactions in exploration phases.

Second, the changing market conditions along the industry life cycle will also affect the nature of the knowledge trade-off, and so the geographical length of knowledge relationships (CRESPO, 2011; SUIRE and VICENTE, 2014). From the era of ferment to the era of incremental change (ABERNATHY and UTTERBACK, 1978), or from the early market to the mass market (MOORE, 1991; AUDRETSCH and FELDMAN, 1996; KLEPPER, 1997), the uncertainty is reduced. The competition shifts from a 'competition for the market' to a 'competition in the market', and process innovations take the lead over product innovations, i.e. the innovative focus shifts from technological properties to productivity improvements, complementarity and compatibility (cost reduction and increase of installed base). Consequently, the terms of the knowledge trade-off evolve. In early stages, the high market uncertainty and the need to impose technological standards give priority to accessibility. However, in mass markets, 'where the dollars are' (MOORE, 1991, p. 41), appropriability concerns rise. This move is reinforced by the shift towards price competition, the reduction of uncertainty and the search for new niche market, either geographically or by differentiation, both requiring distant relationships.

Finally, there are several contextual mechanisms that contribute to reduce uncertainty and opportunistic risks in a relation. They are the social (GRANOVETTER, 1985) and institutional (NORTH, 1990) context of interaction. Interactions inscribed in a context of social and/or institutional proximity benefit from higher mutual trust, lower uncertainty about the partners' behaviour and so a lower risk of opportunism

(BOSCHMA, 2005). Therefore, on the one hand, social and institutional proximities reduce the risk of under-appropriation. On the other hand, they improve accessibility by enhancing the exchange of tacit knowledge and by reducing the costs of searching and monitoring (UZZI, 1996, MASKELL and MALMBERG, 1999). The consideration of social embeddedness and the institutional framework in knowledge relationships contributes to a nuance of the patterns linking the geographical scale of relationships with knowledge phases. Even though geographical proximity favours strong social ties thanks to frequent meetings leading to a higher degree of trust, these ties are not necessarily localized because geographical proximity is only needed at the forming stage of trust (DETMANN and BRENNER, 2010) and thereafter maintained with temporal meetings (TORRE, 2008).

The nature of the organizations, their mutual competences, as well as the market/technology, social and institutional conditions are interplaying parameters that picture a wide range of situations for micro-decisions about the geographical length of relationships. The nature of the structure emerging by their aggregation is the issue of next section.

Structural properties of knowledge networks and TKDs

The multi-scalar hypothesis of TKDs requires the articulation of micro-motives for geographically proximate or distant interactions, and the structure emerging from their aggregation. Indeed, the resulting network structures reflect properties of regional knowledge dynamics at work. Firstly, the aggregation of relationships may produce a cognitive structure with a heterogeneous degree of geographical closure or openness, and highlight the way by which local knowledge dynamics are embedded or not in a wider one. Secondly, in order to disentangle the recurrent question of proximity and distance along the diffusion process of innovations, the closure or openness of the knowledge structure can be analysed by regarding the cognitive attributes of proximate and distant relationships along the knowledge value chain phases. Finally, the analysis of the relational structure in its density and connectivity dimensions can be suited to understand combinatorial knowledge processes and the influential role of some key organizations. The organizational ecology and the variety of knowledge bases observed at the micro-level can be turned into a structural analysis in order to focus on the identification of redundant or missing links, local or not, that may weaken TKDs' efficiency.

In that sense, relational density has often been presented as a critical feature for innovation-based regional policies. However, the above discussion underlines the fact that structures with a similar density may exhibit quite different properties. Consequently, policy action should go beyond density aims by typifying TKDs

according to their particular structural forms (TODTLING and TRIPPL, 2005). Such an effort to identify particular architectures of knowledge flows is suited to understand why some territories succeed in turning local research outputs and new ideas into tradable innovations, whereas others do not.

EMPIRICAL MATERIAL AND METHODOLOGY

This section presents the empirical material used in this paper,¹ with particular attention paid to the information extraction process, and the method of analysis used. CREVOISIER and JEANNERAT (2009) recall that, as an empirical tool, TKDs were defined as a 'bounded systems' in which 'concrete knowledge transformations' can be captured at the interplay of 'regions, sectors and firms dynamics'. All EURODITE case studies have delineated particular systems around the identification of a region and a particular knowledge dynamic, each one attempting to identify a particular composite knowledge domain. Each case study is based on a set of common research questions. In particular, all these case studies have followed the common recommendations that expressed the necessity to capture simultaneously local and multi-local knowledge relationships, anchoring and mobility of knowledge, and how they play together in the combinatorial process of knowledge production. However, detailed methodologies also differ due to the heterogeneous disciplines and backgrounds of scholars involved in the EURODITE Project. Nevertheless, as displayed in Table 1, an attentive reading of each TKD case study enables light to be shed on the key parameters of concern. Rows represent the selected cases, while columns represent the key dimensions underlined by the TKDs concept, at the micro as well as at the structural levels. Sufficient data were found for 17 out of the 23 initial cases retained. They cover regions in ten different European countries and a wide range of sectors, from tourism to biotechnology. The cells represent the quality of data extracted on each parameter, from [0] meaning no information to [+++] meaning high-quality information.

TKDs are composed by heterogeneous organizations with a different valuation of the knowledge trade-off. Reports give information about the nature of the organizations involved in the TKD, classified in three big categories (PROs and other institutions, spin-offs/start-ups, and incumbents and big companies), i.e. the organization ecology. They also give information about the leading position of certain actors to structure the whole TKD. Then the focus is expanded from the organizational nature to its relationships. For each case study, the relevant information on the geographical scale of actors' knowledge relationships and the resulting more or less outwards/inward network structure are collected. Additionally, information is collected on the knowledge bases of

Table 1. *Extracted information from EURODITE case studies*

	Available information in case studies									
	Micro-parameters					Structural parameters				
	Geographical length	Relation contents	Social embeddedness	Knowledge bases	Organizational ecology	Outward-inward structure	Leading organizations	Knowledge value chain	Nature of the knowledge process	Appreciation on missing links
Laser photonics (Aquitaine)	+++	+++	++	+++	+++	+++	++	++	+++	+
Pharma-food (Aquitaine)	+++	+	0	++	+++	++	+	+++	+++	+++
Film (Munich)	++	+	+	+	++	+++	+	0	0	+
Biotechnology (Munich)	++	++	0	0	+	++	+	0	+	0
Information and communication technology (ICT) (Bratislava)	+	+++	+	++	++	+	0	+	+++	++
Global navigation satellite systems (GNSS) (Toulouse)	+++	++	++	+++	+++	+++	+++	+	+++	+
Watchmaking (Switzerland)	+	++	+	+++	+	+	0	+	+++	0
Automotive electronics (South-east Saxony)	+	+	+	++	+	+	+++	+	+	0
Automotive (Baden-Württemberg)	+++	++	+	+++	+++	++	+++	++	+++	+
Car safety (Västra-Götland)	++	++	++	+++	+++	++	++	+	++	++
Nanotechnology (Veneto)	++	+	+	++	+++	++	++	++	++	++
Food industry (Bornholm)	++	++	++	+++	++	+	+	+	++	++
Serious games (West Midlands)	+	0	+	+	++	+	+	+++	++	+++
Biotechnology (Wageningen)	++	++	0	++	+	++	+++	0	++	++
Moving media (Skane)	++	++	+	++	+++	++	+	++	++	0
Tourism (North Jutland)	+++	++	0	+	++	++	++	+	++	++
Automotive (West Midlands)	++	++	+	++	+++	++	+	++	++	+

Note: Cells represent the quality of data extracted on each parameter, from 0 meaning no information to +++ meaning high-quality information.

the organizations, and information on the relational content and their embeddedness in the social sphere is looked for. Their combination enables the cumulative/combinatorial nature of the knowledge process, which is one of the most important contributions to the TKDs concept, and the eventual problems of connectivity defining its effectiveness or potentiality to be identified. Moreover, in order to capture the various patterns of market competition strategy, information about the differentiation strategies adopted by the organizations, either individually or collectively, is selected to construct a territorial differentiation and position it in the global knowledge dynamics. Finally, following a structural purpose, information is extracted on the evaluation of performance of each TKD. This basically refers to the missing organizations, missing links or limiting conditions identified on each case study. This qualitative valuation of the viability and performance of local knowledge dynamics combined with their observed structural properties are suited to draw targeted policy implications.

TKDs can be defined as ecologies of interacting organizations. So the study of TKDs' structural properties, resulting from the aggregation of the organizations' relationships located in the considered area or elsewhere, may be enriched by the use of network analysis concepts (BALLAND *et al.*, 2013). The fourth section elaborates three typologies based on the combination of different properties: local/non-local relations, knowledge phase and connectivity. EURODITE case studies concerning these properties are classified. To do so, the information available in each EURODITE report and obtained from a detailed reading is taken into account. Such classification is further illustrated with direct citations from these reports.

STRUCTURAL CONSIDERATIONS ON TKDs: UNDERSTANDING MULTI-SCALAR KNOWLEDGE PROCESSES FROM STRUCTURAL PROPERTIES OF KNOWLEDGE NETWORKS

This section combines the basic foundations of structural analysis with the empirical materials of the EURODITE Project. Considering that the set of case studies focuses on the identification of particular knowledge dynamics anchored in regions, and the external links that the regions have with other places, EURODITE case studies can be classified according to three sets of critical parameters. Firstly, the multi-scalar features of TKDs are defined according to the respective densities of proximate and distant knowledge relationships in order to evaluate the openness or closure of each TKD and their embeddedness in the global knowledge domain. Secondly, coupling this first result with the analysis of the knowledge value chain of the process and the

knowledge bases of the organizations, the openness and closure of TKDs can be linked to the stages of the knowledge dynamics. Finally, a step beyond density is performed to investigate networks' connectivity and the influence of some brokerage organizations. TKDs can be typified according to the way they succeed, or not, in turning cumulative knowledge processes into combinatorial ones.

Multi-scalar TKDs: structure and geography

The literature acknowledges that local relationships favour innovation. In fact, clusters have been viewed as a panacea of regional development in the knowledge society (MARTIN and SUNLEY, 2003). However, this statement has to be taken with caution because, as discussed above, organizations are confronted with the knowledge trade-off, and relations are costly and risky. Hence, not all relationships are possible. Between a fully connected structure and a highly non-connected structure, intermediate configurations can support a high level of knowledge circulation. As a result, TKDs' performance depends on connectivity as much as on the density of knowledge interactions. This can be appreciated by analysing the features of different structures with a fixed number of knowledge relationships. Fig. 1 summarizes this idea by displaying three kinds of structures composed of 14 nodes (organizations) and ten ties (knowledge relationships) that combine geographically proximate and distant knowledge relationships. This leads to the multi-scalar feature of TKDs.

On the left of Fig. 1, the 'random' network represents a relational structure in which proximity and distant knowledge relationships are randomly distributed. In this structure, knowledge goes in and out the region easily, but a lack of local cohesiveness impedes the knowledge combination process. These structures were typified by MARKUSEN (1996) as satellite platforms. The centre of Fig. 1 displays the opposite pattern: a pure local cohesive structure, i.e. all knowledge relationships only concern local organizations. This structure exhibits a strong cohesiveness that supports a high level of knowledge circulation in the area and many opportunities of knowledge combination. Nevertheless, redundant ties are frequent and the high local density is obtained at the expense of the *outside-the-region* knowledge diffusion and accessibility. The performance of these structures may be weakened by the absence of structural bridges and geographical gatekeepers (BURT, 1992; RYCHEN and ZIMMERMANN, 2008), when innovations and new knowledge have to be turned into dominant designs and mass-market products.

Bridging missing links can increase the structural performance of 'random' and 'closed' networks. New local relationships in the 'random' network increase the cohesiveness of the local structure. Similarly, new distant relationships may reinforce the ability of the collective

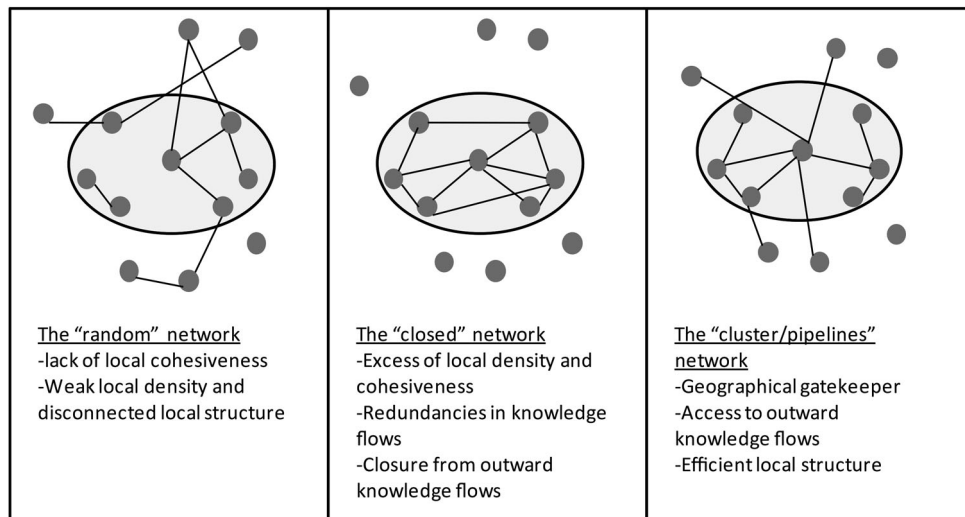


Fig. 1. Multi-scalar territorial knowledge dynamics (TKDs), structural and geographical properties

organization to diffuse and access outward knowledge. Nevertheless, link creation generates costs, so limiting the increase in performance might not be so clear.

The case on the right in Fig. 1 displays a 'cluster/pipelines' network with a reorganization of the same number of relationships. Local cohesiveness is maintained and knowledge can flow in and out the region. Thus, the split in local knowledge relationships observed in the 'random' network disappears, and the excess of redundancies in local knowledge flows in the 'closed' network is reduced. The number of distant knowledge relationships is slightly reduced compared with the 'random' network. These relationships are ensured by 'geographical gatekeepers' (GOULD and FERNANDEZ, 1989; RYCHEN and ZIMMERMANN, 2008), i.e. local organizations that connect disconnected insiders and outsiders and through which knowledge travels in and out. This structure is appropriate for the efficient flow of knowledge with a minimal level of relationships (reducing relational costs), and it enables the embeddedness of the regional system in wider networks and knowledge spaces (VICENTE *et al.*, 2011).

Fig. 2 classifies EURODITE case studies by the openness/closure of their geographical dimension. A variety of structures can be observed. The TKD of Bratislava, Slovakia, focused on the information and communication technology (ICT) sector is typical of a highly dispersed network supported by a weak level of local cohesiveness but a high level of distant relationships mainly supported by the corporate structure of organizations. Following REHAK (2009):

knowledge in the dynamics within MNEs [multinational enterprises] in the ICT sector is mainly distributed via hierarchical inter-firm linkages. Local branches of MNEs thus cooperate with the corporate headquarters, or other branches predominantly in the metropolitan regions (Prague, London, The Hague, San Francisco, etc.).

(p. 23)

Local knowledge relationships exist, but they are mainly supported by market relationships, such as consultancy and the local labour market. The TKD of the Swiss watch industry also displays structural features of a dispersed knowledge network, but with different organizational logics. Indeed, if local interactions are based on a very long and cumulative experience of cooperation in the technical segment of watchmaking, the current dynamics are also highly structured by distant knowledge interactions in a combinatorial process between the watch industry and the worldwide luxury industry, such as motorsport or fashion and design (JEANNERAT *et al.*, 2009), even though local intermediaries as knowledge-intensive business services (KIBS) are required for the integration of knowledge. The TKDs of biotechnology in Munich, Germany, also displays features of a dispersed network. KAISER *et al.* (2009a, 2009b) show that along the knowledge value chain, the distant relationships, highly based on licensing agreements, predominantly take place on a global level: 'By mapping the firms relationships, we examined and found out that by far more collaborations on the international than on the national of cluster-level were forged' (KAISER, 2009a, p. 7). Nevertheless, the Munich biotech TKD cannot be labelled as a pure dispersed/random network. Although most of the young firms build early global relationships, this pattern does not hide the fact that these firms were created through university local spinoffs, i.e. as a form of local knowledge flow.

Secondly, two cases can be identified as illustrative examples of embedded knowledge networks. In the photonic and laser TKD in the regions of Aquitaine and in the global navigation satellite systems (GNSS) in Midi-Pyrenees (both France), the structure of knowledge interactions mixes a high level of local cohesiveness with some well-identified strategic and important

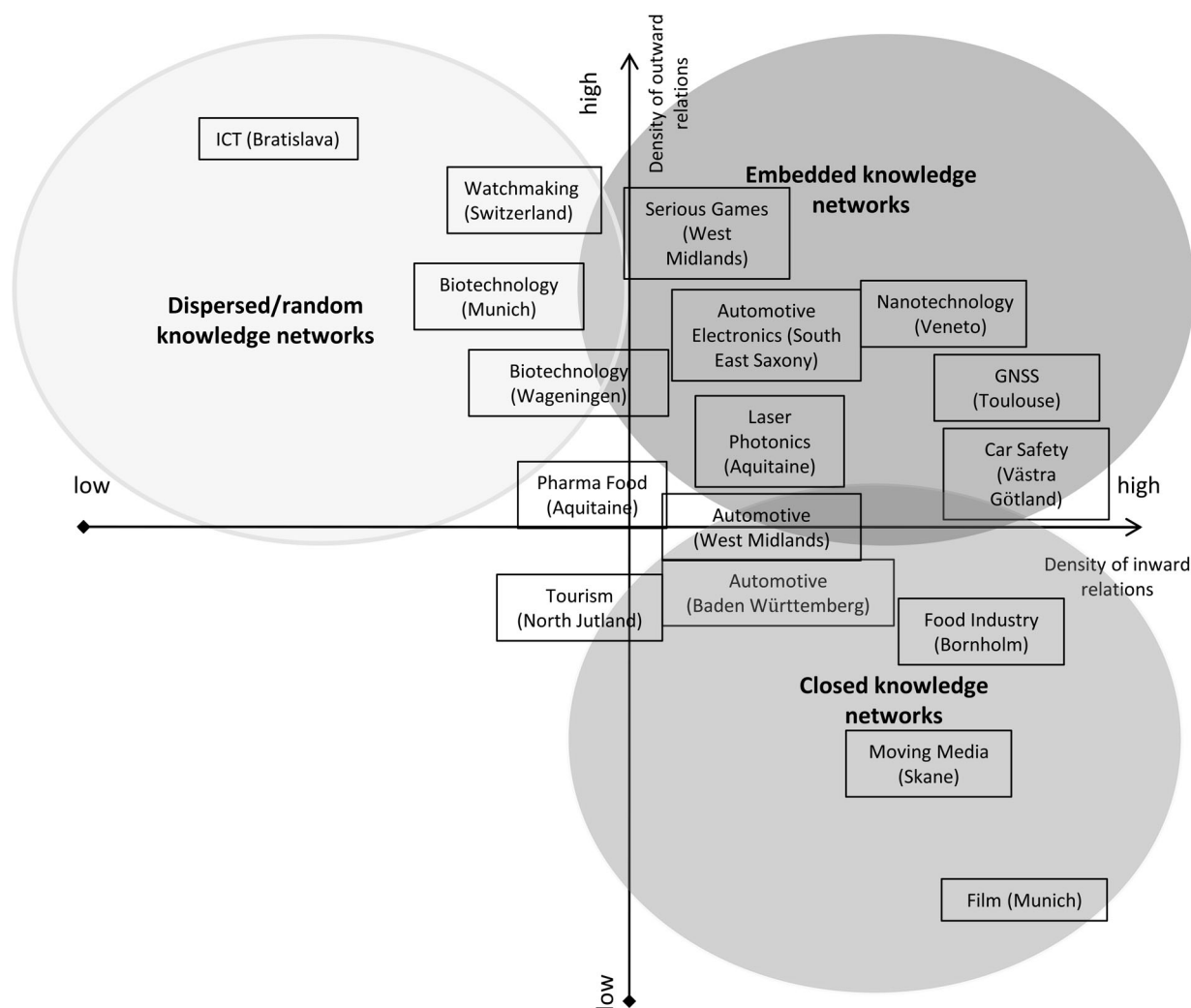


Fig. 2. Openness and closure of territorial knowledge dynamics (TKDs)

distant knowledge interactions. Nevertheless, they differ according to the motivation and key organizations of the embedding process. In the photonics case, the highly cohesive structure of knowledge interactions results from an ecosystem of small and medium-sized enterprises (SMEs), spin-offs and local research teams, while distant knowledge interactions are supported by the belonging of the latter to a global scientific network of PROs. According to CARRINCAZEUX *et al.* (2009), proximate relationships in this TKD are the result of a social embeddedness of interactions rather than the traditional result of the tacit dimension of knowledge. Distant relationships exist by the organizational dimension of French academic research rather than as a consequence of codified knowledge mobility. In the case of the GNSS TKD in Midi-Pyrenees, VICENTE and BALLAND (2009) observed the same local cohesive structure of knowledge interactions between SMEs, spin-offs and two main big companies. But in this case, the cluster is embedded in the whole European GNSS field through the gatekeeper role of local big companies, which connect with other

European companies to get technological integration and standardization in satellite systems. All the embedded TKDs mix this high level of cohesiveness with a minimal and strategic amount of branching with organizations outside the region. They seek for distant relationships to obtain knowledge absorption, diffusion, valuation or cooperation in a dominant design definition.

Finally, some TKDs display the features of closed knowledge networks. The TKD of film in Munich is described by KAISER *et al.* (2009a, 2009b) as a very 'inward looking' relational structure between the players of the feature films value chain, and the industrial organization between production, special effects, funding and distribution is highly concentrated in the cluster. The TKD of tourism in the North Jutland region and the TKD of food in the island of Bornholm (both Denmark) display similar features, with a dense and cohesive structure of local relationships in the knowledge value chain, even though a few set of outward knowledge relationships for marketing are developed.

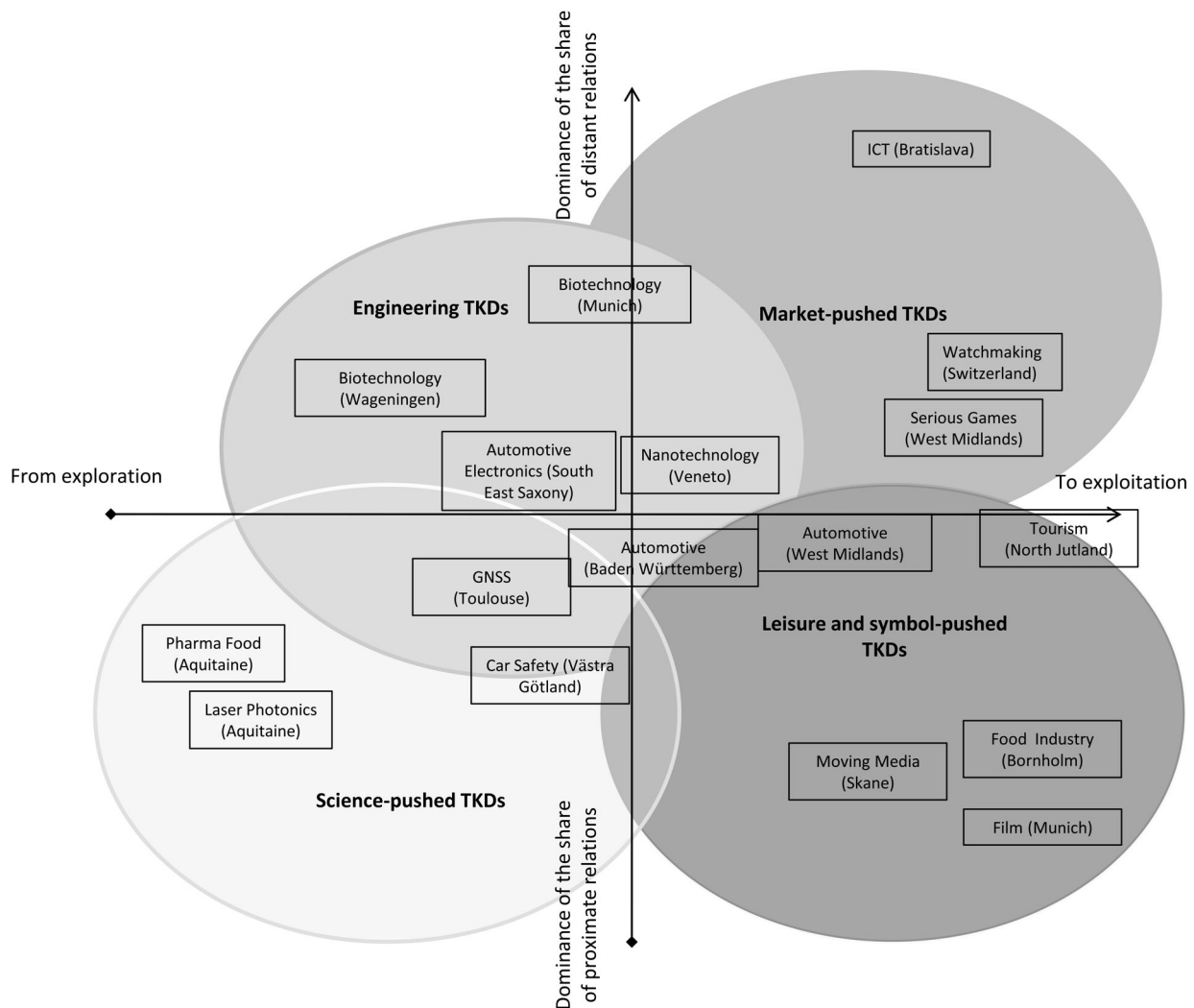


Fig. 3. Territorial knowledge dynamics (TKDs) and the nature of knowledge processes

Proximity and distance along the knowledge value chain

Now, using the information on the organizational ecology, the knowledge value chain and the nature of the knowledge process, the densities of proximate and distant knowledge relationships are combined with the main phase of the knowledge value chain in which the ecosystems of organizations are involved (Fig. 3).

In Fig. 3, *science-pushed TKDs* are featured by a dominant phase of exploration, mainly supported by analytic and synthetic knowledge. For most of these TKDs, this dominant phase can also be supported by global networks and pipelines in the scientific sphere. They help to overcome local limitations on knowledge availability and insert the TKD into a larger domain. In most cases, the knowledge process is highly combinatorial. Therefore, proximity knowledge relationships increase the mutual understanding between cognitively distant organizations. This combinatorial process gives rise to knowledge outputs that are in a very early phase of tradability, focusing on local experimentation, prototype or beta-test. Science-pushed TKDs generally work on

disruptive technologies, far from the mass market and with high uncertainty (MCCANN, 2007). The appropriability concerns of the involved actors are weak. The case of photonic in Bordeaux, France, is typical of a science-pushed TKD (CARRINCAZEUX *et al.*, 2009). Knowledge relationships are mainly concentrated in exploration and examination phases, and a wide range of players are PROs and research spin-offs. Consequently, accessibility prevails over appropriability. The knowledge dynamics are mainly focused on analytical capabilities, and knowledge relationships are dedicated to the photonics fundamentals and to the convergence with other scientific fields such as optic and medical sciences. Purely scientific relationships are partly embedded in a worldwide research community, but scientific relationships dedicated to convergence between photonics and other scientific fields are highly concentrated in the region and mainly driven by PROs. As stated above, PROs are, by nature, less concerned by appropriability issues and have large knowledge bases to fill cognitive gaps. The examination phase is mainly supported by local spin-offs, coming

from research rather than from industry. Big companies are not really involved in the knowledge process. The TKD is in the very upstream phase of the early market and with experimentation prevailing over tradable applications. The case of GNSS in Midi-Pyrenees is close to the previous one (VICENTE and BALLAND, 2009). The knowledge process in GNSS is supported by local knowledge relationships in the exploration phase, where distance between partner cognitive bases and distance to the market are still large. The examination phase is dual. Local relationships matter when the purpose is to integrate navigation solutions in existing technological systems such as transport, telecommunications or security. Global relationships matter when the purpose is to ensure interoperability and compatibility between the main European players of the satellite industry, i.e. to insert the local TKD into the global domain.

In *engineering-pushed TKDs*, examination process and knowledge integration between existing technologies and knowledge prevail. Exploitation is reachable for these TKDs, and local knowledge relationships in the examination and engineering processes coexist with global ones for knowledge tradability where appropriability becomes a leading force. Engineering-pushed TKDs generally evolve through incremental innovations rather than through disruptive ones. The risk of unexpected spillovers undermining appropriability increases the dominance of distant relationships. The two cases of automotive TKDs of the regions of Lower Saxony (BLÖCKER and JÜRGENS, 2009) and Baden-Württemberg (STRAMBACH *et al.*, 2009) (both Germany) are typical of engineering-pushed TKDs. Integration between automotive and electronic devices and software are supported by a cohesive local structure of knowledge relationships between players of these separated technological fields. SMEs find new market opportunities for their products, while automotive companies integrate new technologies in their products that can be diffused worldwide through their corporate structure. In the case of automotive electronics in Lower Saxony, geographical proximity matters for knowledge transfer from aeronautical electronics to automotive systems, while the international corporate structure of Volkswagen, as well as the 'Automotive Electronics Alliance' supported by the German federal government, contributes through corporate integration and cooperative agreements to the worldwide exploitation of German quality and innovation standards in the automotive industry.

Market-pushed TKDs are concerned with mature technologies and knowledge is based on well and largely established standards. Organizations in these TKDs are embedded in larger networks. So the combinatorial process does not occur locally but is integrated within the corporate structure of multi-plant organizations. The dominance of the exploitation phase, the prevalence of market relationships and the cognitive

proximity among local actors explain the marginal role of PROs and spin-offs as well as the high proportion of distant relationships. The ICT case of Bratislava fits in to this type of TKD (REHAK, 2009). Most of the companies located in the area are subsidiaries of worldwide software companies dedicated to the exploitation of their knowledge of the European market. Research and exploitation are mainly realized within the corporate structure. Relationships with local universities and schools are mainly dedicated to training and labour market.

In the *leisure and symbol-pushed TKDs*, exploitation phases prevail as in the market-pushed TKDs. However, market proximity does not hamper a high concentration of local relationships, because the specific nature of the exploited resources requires cooperative strategies among direct competitors. The symbolic dimensions of knowledge outputs are built and preserved by local, social, and economic arrangements and partnerships. Combinatorial processes, when they occur, concern exploitation phases: marketing and quality. The Bornholm TKDs on regional food correspond to this kind of TKD (MANNICHE *et al.*, 2009). Even if the knowledge dynamics are market-pushed, niche strategies lead to very cohesive structures of local relationships between complementary organizations (food, tourism, marketing). Knowledge relationships are mainly dedicated to symbolic knowledge. They combine very local interactions in the integration phase of the capabilities of each sector with more extended relations in the Danish perimeter in the exploitation phase. A close pattern is observed in the feature films TKD of Munich (KAISER *et al.*, 2009a, 2009b). The niche market strategy of the main organization implies a region-based relational system in the exploitation phase. This local cohesiveness is a source of market but also cultural differentiations, since 'the TKD displays an exploitation of market niches within the domestic sphere of feature films where Hollywood productions generate a much lower stress of competition' (KAISER *et al.*, 2009a, p. 21).

Structural properties of TKDs: connectivity and viability

The relational structure of each TKD is composed of organizations that differ by their knowledge and structural profiles. As shown in the second section, big companies, SMEs, PROs, regulation agencies or KIBS etc. develop different relational strategies concerning knowledge because they face different constraints in the knowledge trade-off. If one goes beyond density to study TKDs' viability, the focus should be on the role of (sometimes few) relationships supporting the combinatorial knowledge process and the links along the phases of the knowledge value chain. Therefore, the organizations weaving these relationships will play a critical role in the connectivity of the knowledge network (Fig. 4).²

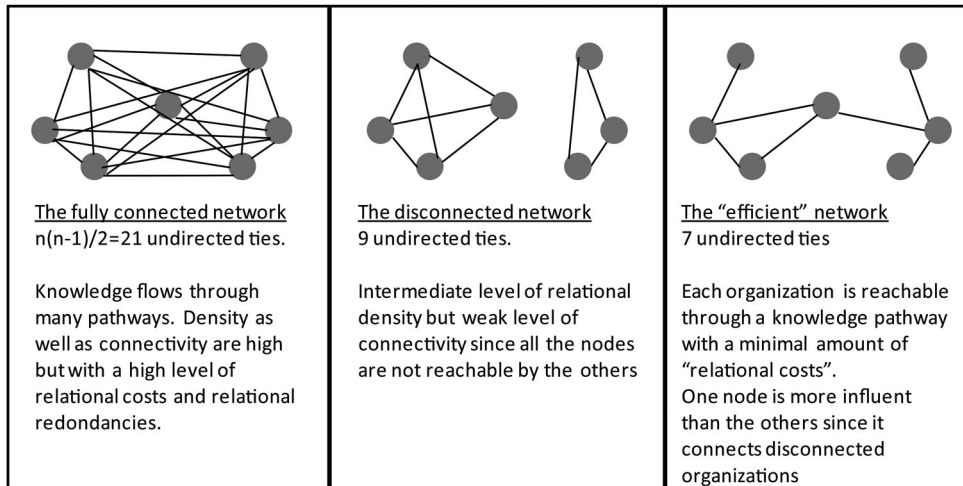


Fig. 4. Knowledge networks' density and connectivity

A fully connected regional network (the left-box in Fig. 4) may weaken structural performance. Organizations select their number of partners in the tension between getting a sufficient level of knowledge accessibility and minimizing costs. As discussed in the second section, the selection process is influenced by past relationships. Satisfactory past experiences increase trust between partners and reduce relational costs. Following BURT's (1992) researches on network efficiency, fully connected networks are not efficient because of an excess of redundancies. Indeed, from a structural perspective, knowledge does not only flow through direct ties. Indirect ties may create different pathways, different channels, through which knowledge waters the whole structure (OWEN-SMITH and POWELL, 2004). This requires intermediary network density in which each organization can reach all others through a limited number of pathways and steps (the right-box of Fig. 4). In these structures, particular relationships and actors exhibit a high level of strategic influence. Removing them implies a split of the whole network, and thus an eventual failure in the combinatorial knowledge process ('disconnected network'). Thus, relational density matters for innovation, but connectivity also plays a critical role. Some 'missing links' can have a higher importance than others for the

TKDs functioning and viability. The focus here is on these few but critical organizations acting (or not) as interfaces, ensuring connectivity, to favour the combinatorial knowledge process and the diffusion of knowledge along the phases of the knowledge value chain. They are crucial to a better understanding of why some TKDs succeed and others fail in ensuring their viability.

EURODITE reports show that gatekeepers and knowledge interfaces can be ranked according to three categories (Fig. 5), each one involving organizations that bridge cumulative knowledge dynamics and turn them into combinatorial ones along the knowledge value chain. Firstly, PROs generally play a connecting role for TKDs involved in science-pushed knowledge dynamics and early markets. PROs are 'leakier organizations' than firms (OWEN-SMITH and POWELL, 2004). Due to their model of knowledge management, they play a critical role in connecting disconnected knowledge dynamics and engender new phases of combinatorial knowledge exploration. Secondly, KIBS play a similar role, in particular for TKDs involved in engineering phases. Due to the composite nature of KIBS knowledge and their ability to provide solutions for knowledge integration, KIBS provide an interface between technologies and markets (STRAMBACH,

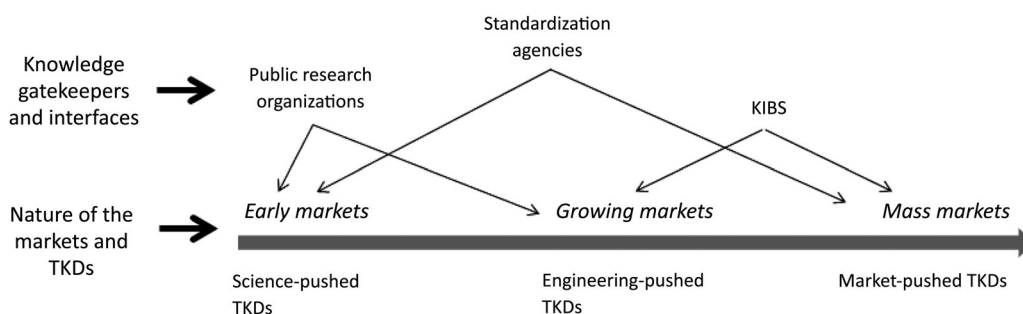


Fig. 5. Knowledge gatekeepers and interfaces in territorial knowledge dynamics (TKDs)

2008). Thirdly, standardization or normalization agencies also play a salient role in the development of regional combinatorial knowledge processes by reducing uncertainty on new markets development. The more organizations face norms and standards, the more they invest in these emerging markets and develop relationships to combine their knowledge with the knowledge coming from other domains around new consumer standards. This particularly applies to companies. As a consequence, the interface role of standardization agencies, at proximity or distance, is crucial in the knowledge dynamics that turn a very early market into a mass market. Their action is particularly important for engineering-pushed TKDs.

Fig. 6 highlights these connectivity considerations in EUROTITE case studies. The horizontal axis displays the different types of TKDs identified in Fig. 3. The vertical axis represents the existence or absence of the gatekeepers and interfaces that connect (or not) otherwise disconnected organizations and pools of knowledge.

In science-pushed TKDs, combinatorial knowledge processes seem to succeed when PROs appear as the main knowledge interface. In the photonic case of Aquitaine, PROs connect their worldwide scientific networks with the local milieu of spin-offs, leading

external knowledge to be turned into knowledge inputs for the cohesive structure of local relationships. PROs 'water' the local structure:

combinatorial knowledge interactions that are involved in the diversification of photonic applications [...] are also associated with a high degree of territorialisation of the relationships. A first reason seems to be the facilitation, by an effect of proximity, of knowledge interactions between firms and local laboratories having heterogeneous competences.

(CARRINCAZEUX *et al.*, 2009, p. 40)

VICENTE and BALLAND (2009) observe a close pattern in the GNSS technological field in Midi-Pyrenees. The creation of a federative research institute – TESA – that gathers researchers from satellite and telecommunication knowledge domains, has favoured the combinatorial process: 'TESA wants to be the missing link between research and development of services and applications for users. TESA appears as a 'leaky' interface, which diffuses knowledge between the different cognitive segments' (VICENTE and BALLAND, 2009, p. 26).

In engineering TKDs, the connecting role is ensured by KIBS. The case of the automotive industry in Baden-Württemberg is illustrative of the role some

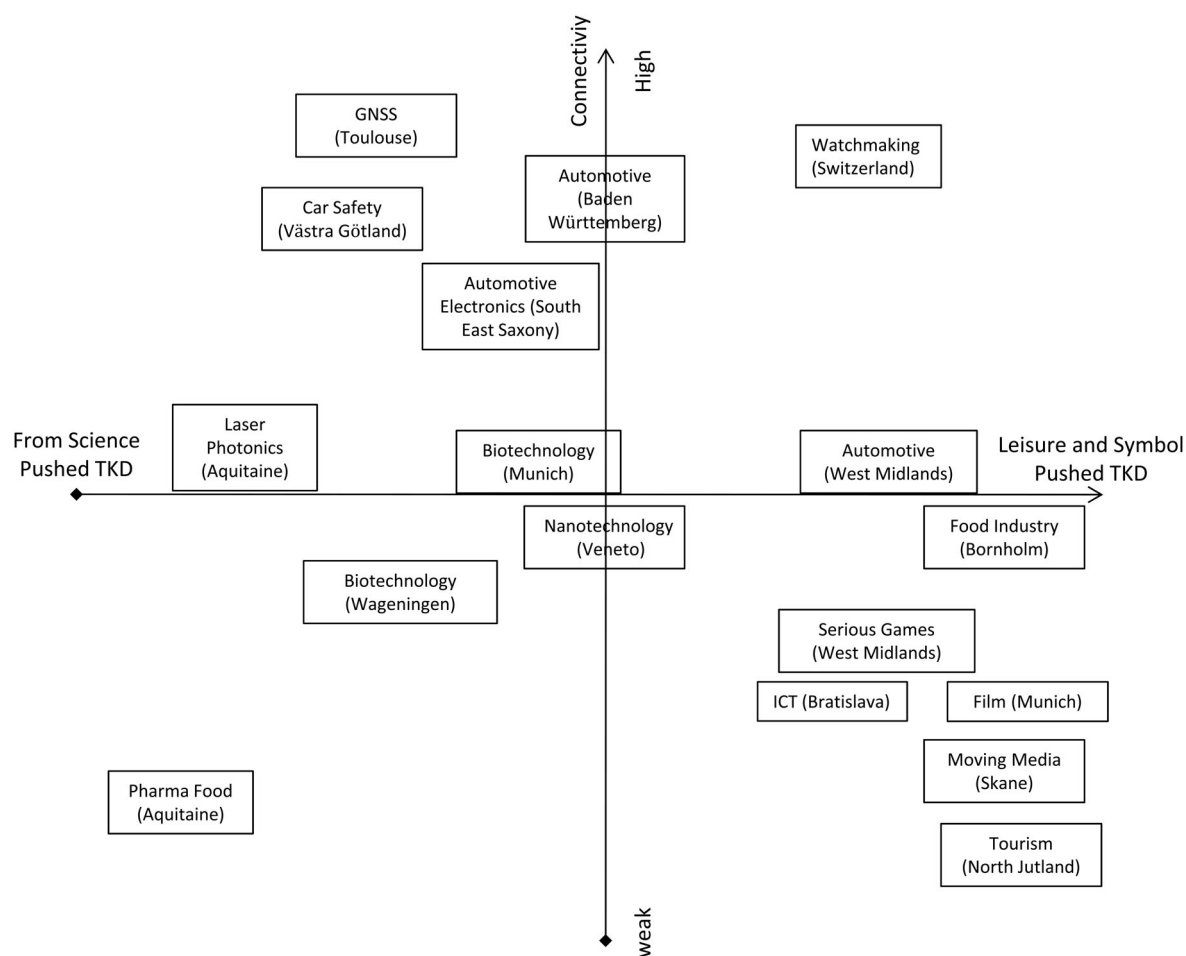


Fig. 6. Territorial knowledge dynamics' (TKDs) knowledge network connectivity and the nature of knowledge processes

strategic intermediaries play in the combinatorial knowledge integration. In Baden-Württemberg, KIBS are identified as the necessary interface of the modular system in which cognitive barriers exist and need to be overcome:

KIBS seem to contribute crucially to the creation of composite knowledge since they are able to build up missing technological, organizational or cognitive proximity. It could be also observed that existing proximity barriers hinder the knowledge transfer across sectoral boundaries; in these cases firm intern and extern KIBS are characterised by their knowledge products which contribute to overcoming these existing proximity barriers.

(STRAMBACH *et al.*, 2009, p. 26)

Similar facts are observed in the automotive case of Lower Saxony, the very cohesive structure of start-ups working on embedded systems for the automotive industry finds technological bridges with aeronautics through the coordination role of KIBS, which 'form not only the link between various sectors but also constitute an important knowledge resource since they are often specialised in introducing non-automotive knowledge from regional and from global networks into the existing TKD' (BLÖKER and JÜRGENS, 2009, p. 20).

Standardization and normalization agencies facilitate the emergence of combinatorial knowledge processes in some TKDs. They reduce uncertainty on market opportunities and enhance relationship construction between organizations that decide to combine cumulative knowledge processes with more composite ones. For instance, in the TKD of GNSS in Midi-Pyrenees, the role of the French Spatial Agency, and more generally the role of the European Spatial Agency, have defined new standards in navigation systems: 'the geographical gatekeeper role of French Spatial Agency marks its willingness to impose standards in the technological field by insuring the knowledge accessibility and flow in the whole of the Midi-Pyrenean network' (VICENTE and BALLAND, 2009, p. 30). Relationships between satellite companies and other organizations belonging to different sectors and those interested in the development of applications are enhanced by the uncertainty reduction on technological interoperability and compatibility. The same trend is observed in Lower Saxony with the automotive industry. The standardization agency Autostar works as an intermediary between original equipment manufacturers (OEMs) and automotive software providers. The role of this agency is crucial due to the necessary European interoperability between automotive embedded systems: 'Cooperation in this field takes place through the AUTOSTAR network, jointly developed by automobile manufacturers, suppliers and tool developers, by means of which participants hope to eliminate problems through uniform standards by the end of 2009' (BLÖKER and JÜRGENS, 2009, p. 31).

The study of such bridging organizations and their role illustrates how combinatorial knowledge processes occur in territories, and how the structural dimension matters to reach a high level of territorial creativity along the knowledge value chain. In fact, their absence, the existence of key missing links, may lead to TKDs' failure. One of the striking examples of 'missing links' appears in the pharma-food TKD in Aquitaine. Following the new paradigm of functional and nutritional food, the region displays a high potential of food and pharmaceutical firms, but with a weak level of cooperation between both sectors. The main reason for this disconnection lies in the strong uncertainty that remains about norms and standards concerning the evolution of these emerging markets: 'If cooperation between agrifood and pharmaceutical domains remain weak at the local level, one can expect that EU legislation will act as an important incentive' (CARRINCAZEAUX *et al.*, 2009, p. 10). In spite of a high level of production of analytic knowledge in the field of local PROs, this uncertainty about market perspectives impedes the combinatorial knowledge process in the engineering and examination phase. An increase of knowledge transfers between PROs and firms, and an expected clarification on the European standards of functional and nutritional food, would allow the very explorative and isolated local knowledge dynamics to be turned into a central place in this growing market.

Another illustration of the role of missing links comes from the case of nanotechnologies in the Veneto region of Italy. The persistence of cumulative knowledge dynamics has brought local SMEs to mature industries with strong competitive pressure. Upgrading through the requalification with technological innovations was hampered by the historical weak collaborations between industrial sectors and the university research system due to the cognitive gap existing between them:

The difficulties encountered were connected to the distance between two different epistemic communities: one, that of researchers, focused on the specific dimension of the experimentation and on its specific language; the second, that of SMEs representatives, characterized by the strong attention towards products and processes and quite distant, in cognitive and cultural terms.

(FINOTTO, 2009, p. 14)

In order to fill the gap, two sets of interactions have been developed: interactions among professionals in SMEs and regional PROs, and interactions among organizations themselves.

Similarly, the plant biotechnology TKD in Wageningen, the Netherlands, shows how combinatorial knowledge processes, involving PROs in plant biotechnology and industrial firms in related sectors such as plant breeding or food industry, fail to emerge because of the problems of Wageningen University to assume its brokerage role as a local cognitive coordinator. In spite of the strength of research capacities of the

university, its cognitive lock-in by its labour division and its focus on genetic modification with low public acceptance have increased the distance between scientific and industrial world objectives.

POLICY PERSPECTIVES FROM TKDs: FROM THE DENSITY RULE OF 'CONNECTING PEOPLE' TO THE TARGETED AND SURGICAL INTERVENTIONS OF 'MISSING LINKS'

Using the empirical material of the EURODITE Project, this paper discusses geographically proximate and distant knowledge relationships at two levels: (1) the micro-level, to understand the motives for building knowledge relationships; and (2) the structural level, to understand the organization of knowledge processes along the knowledge value chain, the knowledge domains and the geographical space. Different patterns of TKDs with different performances appear. This diversity invites one to go beyond an univocal way of thinking about knowledge-based regional policies. Policies usually focus on increasing the density of knowledge interaction as a source of regional performance. In that sense, cluster policies are a common example (McCANN and ORTEGA-ARGILÉS, 2013). However, if one takes into account the variety of TKDs, this single solution may be under-performing. Indeed, more surgical and precise interventions, focused on some particular proximate or distant missing links, can favour the regional dynamics as a whole.

In terms of the first typology, dispersed and random networks need policies that focus on the enforcement of the local cohesiveness of the relationships. Closed networks, on the other hand, need connections between the regional ecosystem and the global technological domain. Likewise, traditional cluster policy can fail if it is applied in an undifferentiated way. Undifferentiated policies incentivizing local knowledge relationships remain efficient in a context of dispersed or random networks, because they favour knowledge combination. However, they may be inefficient for closed networks, because they tend to reinforce the pre-existing and redundant relationships rather than building local-global structural bridges helping to go from niche markets to mass markets.

The second typology is focused on the links between the knowledge value chain and the geographical extent of knowledge relationships. Here policy implications differ according to TKDs' positions. For instance, science-pushed TKDs do not face the same constraints of development or incentives as leisure and symbol-pushed ones. For science-pushed TKDs, the main policy purpose is to nurture incentives and a means to turn new innovations into tradable applications, products and services. For market-pushed TKDs, in contrast, the long-term viability of the attractiveness of

the place needs to be supported by a higher level of research and analytic knowledge to overlap the exploitation in the mass market with exploration in related emerging markets (CRESPO *et al.*, 2014).

Finally, a targeting on particular missing links rather than a general watering of public funds for collaboration is suited for 'repairing' particular connectivity problems. The discussion revealed that sometimes few relations or nodes are missing for the knowledge dynamics to enable the convergence between knowledge processes, and so incentives and policies need to be more surgical. TKDs' failures are not always of the same nature and in the same stage. The synthesis realized here gives a possible interpretation of these failures and points out some policy directions. For instance, when an early market and an associated TKD are identified, policies should focus on the way standard settings may enable emerging technological fields to reach mass markets. The Global System for Mobile Communications (GSM) European policy in the early days of the mobile phone industry is a good illustration. In parallel, when the exploration in emerging fields displays failures in the coordination process of knowledge combination between private organizations, incentives to create and support PROs that promote knowledge as a local commodity for private organizations in place should be favoured. Moreover, for incremental innovations, policies should support KIBS, because these organizations are effective interfaces between cognitively distant players and reinforce their mutual understanding.

CONCLUSIONS

This contribution has studied the structural diversity of TKDs and how they influence their viability and performance. The point of departure is the micro-motivations of organizations to construct knowledge relationships and how they use proximate and distant relationships to deal with the knowledge trade-off. The aggregation of these individual relations produces particular TKDs structure exhibiting different performances and capacities to organize viable knowledge process along the knowledge value chain. Three structural dimensions of TKDs are highlighted. Firstly, the need to combine local and non-local relationships. Secondly, the geographical openness of the structure along the knowledge value chain. Finally, the density versus connectivity debate and the role of certain key non-redundant relations. From this discussion the need to be careful about the design of policies to boost relationship creation is defended. Facing the different structures of TKDs, the application of undifferentiated policies may not yield the expected results, i.e. the popular tendency towards density increases as a single recipe may be ineffective in certain contexts. Therefore, the claim is for the design of more 'surgical' policies incentivizing the

creation of the necessary missing links some TKDs can exhibit.

Finally, the exploratory concept of TKDs has inspired new and interesting ways to capture empirically knowledge dynamics in regions and some regular patterns of knowledge-based regional development processes. By introducing the complex articulation of proximate and distant knowledge ties along the knowledge value chain, and the way with which they play together in the production of composite and combinatorial knowledge, this new approach is consistent with the growing literature that calls into question the over-emphasis on local relationships, face-to-face contacts and local knowledge spillovers. Indeed, the findings confirm the results of other researches that show that the geography of innovation combines various patterns of knowledge interactions according to the nature of product innovations and their life-cycle phases (McCANN, 2007, BRENNER and SCHLUMP, 2011, SUIRE and VICENTE, 2014).

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NOTES

1. This paper has empirical material in common with the other papers in this special issue, i.e. EUODITE Project reports.
2. Connectivity refers to the ability of the relational structure to render reachable for an agent any other agent in the structure.

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