Chapter 5
Transformative paths, multi-scalarity of knowledge bases and Industry 4.0

Marco Bellandi[1]
Cristina Chaminade [2]
Monica Plechero[3]

Abstract: This chapter proposes a novel conceptual framework to understand how different knowledge bases (analytic, synthetic and symbolic) can be accessed and combined at different territorial scales, by looking at which mechanisms can be used to favor positive transformational paths in local productive systems. We apply such framework to the role of combinatorial knowledge for sustainable transformations in relation to challenges posed by Industry 4.0 (I4.0). Case studies presented in the MAKERS project illustrate the multi-scalarity of knowledge bases that can be combined in different paths of industrial transformation addressing models of I4.0 including so-called I4.0+ alternatives.

Keywords: Combinatorial knowledge bases, internationalization, I4.0, Makers Project, path transformation

1. Introduction

This chapter discusses the role of combinatorial knowledge and its multi-scalarity in shaping the transformation paths of local productive systems (**LPS**) that are under the gales of contemporary technological change. Specifically, we look at how access to and combination of different knowledge bases at different territorial scales (local/regional, national, international/global) can support different paths of industrial upgrading for LPS in face of the challenges posed by Industry 4.0 (**I4.0**). We adopt the **I4.0+** (plus) perspective defined in Chapter 1 which aims to address sustainable development.

Local and regional transformation paths increasingly rely on complex knowledge dynamics (Grillitsh et al., 2018), that require different types of knowledge to inter-relate in order to support some degree of innovativeness in local systems (Asheim et al., 2017; Grillitsch et al., 2017). Such knowledge dynamics refer not only

[1] PhD, Full Professor in Applied Economics, Dept. of Economics and Management, Florence University, Via Pandette 9, 50127 FIRENZE, Italy, marco.bellandi@unifi.it.
[2] PhD, Full Professor in Innovation Studies, Dept. Economic History, Lund University, Box 7083, 22007 LUND, Sweden, https://cristinachaminade.wordpress.com, cristina.chaminade@ekh.lu.se
[3] PhD, Research Fellow in Applied Economics, Dept. of Economics and Management, Florence University, Via Pandette 9, 50127 FIRENZE, Italy, monica.plechero@unifi.it.

to knowledge that has different degrees of transferability across spaces (tacit vs. codified knowledge), but more crucially it involves different knowledge bases: synthetic (science based), analytic (engineering based) and symbolic (cultural based) (Asheim and Gertler, 2005; Asheim and Coenen, 2005).

Traditionally the literature on knowledge bases has argued that synthetic and symbolic knowledge -both with a high tacit content- tends to be accessed only when actors are in close proximity and with limited international interactions (Martin and Moodysson, 2011, 2013). In contrast, analytic knowledge - which has a higher codified content – tends to be accessible at a wider geographical scale. However, recent evidence suggests that also synthetic and symbolic knowledge can be sourced at an international level, which extends the possibility for accessing and combining all knowledge bases at different geographical scales (Martin et al, 2018).

In this paper, we build on such suggestion, and propose a novel conceptual framework that attempts to match different transformative paths with different combinatorial knowledge creation. We assume that matching might involve different knowledge bases that are sourced at all geographical scales: from regional to global. Furthermore, we will discuss how effective sourcing depends on the use of specific mechanisms and on the presence of place-specific conditions (Section 2).

This extended framework will be applied to better understand how access to knowledge and any of its combination can shape alternative models of value creation in LPSs that are embarking on transformative or renewed paths of development, to take advantage of the opportunities opened up by I4.0. In particular, digital technologies characterize the core of the I4.0 model, and may unlock and enable new value creation solutions within LPSs, that will impact not only on the economic growth of places, but also on their societal development (OCSE, 2016; Word Bank, 2017). On one side, I4.0 is pushed by the increasing importance of analytical/scientific knowledge supported by digital coding. On the other side, the outcomes of innovation processes underpinned by I4.0 include an ever-deeper combination of product, service and societal contents. This implies the necessity of accessing both synthetic/engineering and symbolic/cultural knowledge on complex multi-scalar settings (Section 3).

In a last final part of the chapter, we will discuss these issues in relation to a number of case studied within the MAKERS project (Section 4).

2. Access and combination of different knowledge bases in LPSs' transformative paths

2.1 Knowledge bases and local path transformation

As already recalled, there is a stream in the innovation literature that argues that local/regional path transformation is favored when different types of knowledge can

be accessed, combined and effectively integrated.[4] Combining different types of knowledge is indeed a distinct feature of current innovation processes transforming the nature of a large number of industries (Strambach and Klement, 2012; Grillitsch and Trippl, 2014, Corradini and De Propris, 2015). This is even more so in the context of disruptive technological challenges brought by Industry 4.0 and when there is a need to pursue sustainable societal as well environmental goals (Strambach, 2017).[5]

Attending to the degree of codification and the processes of knowledge creation, Asheim and Coenen (2005) and Asheim and Gertler (2005) distinguish between three types of knowledge bases:

- *Analytic knowledge (science based)* is often created with the application of experiment-based methods. The value is extracted from the application of scientific principles and theoretical modes of learning. Many of its content can be transferred in a codified form (lectures, reports, publications, patents). Often firms rely on collaboration with research organizations for its creation and on R&D laboratories for its absorption.
- *Synthetic knowledge (engineering based)* relies on inductive processes of problem-solving. In production contexts, it is associated with the engineering of new results emerging from doing, using, and interacting (DUI) forms of learning (Jensen et al., 2007). The value can be extracted by means of socialization and synthesis of the existing knowledge (Herstad et al., 2014).
- *Symbolic knowledge (cultural based)* concerns cultural contents, aesthetic as well as immaterial values. Its creation relies on a variety of heritage and life notions and images elaborated by means of trained artistic and cultural intuition. The value can be extracted from creativity and contextualized sense-making. Whilst, it is highly place specific, as the interpretation of images, design, and symbols varies significantly from one location to another, it can also be embedded in artefacts and media communications by means of design and various types of applied and performing arts.

Due to its mostly codified nature, analytical knowledge could be accessed across large geographical distances and, consequently, industries dominated by analytical knowledge bases tend to display a high propensity to establish international networks. Whereas synthetic knowledge combines elements of tacit and codified nature and, as a consequence, such knowledge can be acquired more through local networks and only to a lesser extent through international networks. Finally, symbolic knowledge creation processes tend to rely significantly on local knowledge networks (Bathelt et al., 2004; Martin, 2011).

[4] See in particular the special issue on Knowledge bases in Economic geography: vol. 93 (5), 2017.

[5] In this latter case, the generation of value derives often from the convergence of unrelated knowledge bases taken from different sectorial contexts and recombined in traditional sectorial specialization (Grillitsch et al., 2017).

When we consider processes of local or regional transformation, should access to different knowledge bases as well as their combination be limited, a high risk of path exhaustion if not decline would materialize. On the contrary, when different types of knowledge can be accessed and effectively combined by local actors, this may lead to some forms of path upgrading. Whereas, new path creation would require a high degree of combinatorial knowledge, which implies often an extensive use of differentiated knowledge bases as well as complex multi-scalar interactions.[6]

While some of the initial literature on knowledge bases tends to suggest that synthetic and symbolic knowledge will be sourced in local and regional networks while analytical knowledge can be sourced at the international level (Martin and Moodysson 2011, 2013), Martin et al. (2018) suggests that different knowledge bases supporting the processes of transformation of LPSs can be acquired at different scales depending on needs and capabilities of the specific firms. However, they fall short of explaining how this occurs and which mechanisms are more likely to be activated to access the different types of knowledge and at which different geographical scale. This paper fill this conceptual vacuum.

2.2 Multi-scalar mechanisms for knowledge access and combination in local productive systems and knowledge-led transformative paths

A key issue that emerges from the literature that links knowledge bases to transformative paths is that effective combinatorial knowledge processes require local and global spaces to be bridged or connected. Such connections need to be better understood.

At the local level, firms and supporting organizations may use a variety of mechanisms to access different knowledge bases (Trippl et al., 2009): such as market mechanisms, networks (e.g. alliances), hierarchies (e.g. via the operations of multi-national corporations) and spill-overs (e.g. mobility).

In particular, knowledge is typically exchanged in *markets* when it is embodied in goods or services whose value is potentially easy to measure. Such embodied knowledge is likely to correspond to analytic or codified synthetic types of knowledge. Typical examples would be the use of patents for a new drug development, or the acquisition of machinery for a specific engineering process.

Fragments of all types of knowledge may be accessed via *unintended spill-overs* associated with human capital mobility, the monitoring of competitors, or informal single or repeated face-to-face contacts. Spill-overs tend to occur in close geographical proximity, although larger geographical distances are not excluded, for example through international mobility (Rosenkopf and Almeida, 2003; Song et al., 2003) or temporary geographical proximity (Torre, 2008).

[6] Various contributions develop concepts and cases around such relations. See Asheim et al., 2011, 2017; Chaminade et al., 2017, 2018; Grillitsch et al., 2017, 2018; Isaksen and Trippl 2016; Manniche et al. 2017; Trippl et al., 2017.

Networks, on the other hand, are based on trust and reciprocity (Powell, 1990). The reciprocal character of network relationships implies that actors have similar or complementary absorptive capacity as well as frequent face-to-face interactions and/or the sharing of habits and collective rules. Networks are a good mechanism for the transmission of know-how and know-who and, in that respect, they are likely to be used for the collaborative transfer and the absorption of tacit contents prevailing in synthetic and symbolic knowledge. Networks for knowledge creation and innovation can take different forms: R&D contracts, alliances, research consortia, epistemic communities or communities of practice.

Finally, *Hierarchies*, which can be inter-firm and intra-firm, are mainly based on power enforcement together with the sharing of private rules, common routines or a history of previous interactions. Those characters reduce institutional distance also across space (Martin and Salomon, 2003). By opening subsidiaries in different locations, multinational corporations (MNCs) can access and absorb tacit and codified synthetic knowledge belonging to different scientific and technological fields that has been accumulated in different countries or regions around the world (Kafouros et al., 2012).

The propensity of firms to use different mechanisms to access distant knowledge will ultimately depend on the availability and transferability of knowledge as well as of firms' capabilities. By availability we refer to the degree of concentration of that knowledge in specific regions around the world. The sources of highly novel analytic knowledge, highly specialized synthetic knowledge, or key symbolic knowledge are sparse and often highly concentrated in specific locations (knowledge hubs). This means that firms located in knowledge hubs have an advantage in terms of access to such knowledge without the need to engage in extra-regional linkages. However, having access to knowledge is not enough. The ability of the organization to tap into pools of knowledge is strongly related to its absorptive capacity. Transferability is the possibility to transmit and receive knowledge without noise, bias, leakages, and depends on the degree of codification. Hence, availability, absorptive capacity and transferability determine what mechanism firms avail themselves of to access knowledge at different geographical scales.

The questions is therefore: At what different geographical scale do the above mentioned mechanisms help firms and related organizations access different knowledge bases and trigger combinatorial knowledge creation processes enabling local transformations?

We focus our analysis on *local productive systems* (LPS) (Becattini and Rullani, 1996): these are (relatively) small regions (urban or rural areas, industrial districts, etc.) featuring one or a few productive specializations, more or less complementary. The specializations are related to the activity of a cluster of firms and supporting business and public organizations operating in the place. Productive decisions and activities have key roots in local business and socio-cultural and institutional networks.

Table 1 provides a schematic summary of the main mechanisms supporting the access of LPS to different types of knowledge bases that can be levered at different

geographical scales. The *appropriateness of the mechanisms* and their role for path transformation in LPS depend on the wealth of knowledge sources in LPS and the type of proximity that can be used when accessing different knowledge bases[7].

---- TABLE 1 around here ----

In *transformative processes*, market mechanisms are used by companies to access internationally available analytic knowledge, for example, through patents (Herstad et al. 2014). However, firms whose innovative processes are driven by the creation and/or the development of new analytic knowledge, either cluster in highly innovative hubs around the world, or tend to link to key players themselves located in international knowledge hubs. Networking in this case is a preferable mechanism for distant interactions. Firms located in LPS with strong research infrastructure are also more likely to have high technological capabilities enabling them to actively participate in research networks at a global scale.

Networks and spill-overs facilitating or implying face-to-face interaction are likely to be used intensively for accessing synthetic knowledge at different geographical scales. Networks in general are likely to work better at local or national levels where institutional distance is limited (Martin and Moodysson, 2013; Mattes, 2012). When accessibility to synthetic knowledge is low or networks and spill-overs at the local level fail to provide new input for generating value, firms may decide to use the hierarchical channel by opening for example a subsidiary abroad (offshoring of R&D) to acquire synthetic knowledge from a distant location (Liu et al., 2013). The MNC might bring in knowledge accumulated from networks with other places that can be reapplied and re-used differently in the host location.

On the other hand, symbolic knowledge is highly context specific and tacit, moving with individuals or being embedded in specific communities (e.g. communities of practice, epistemic communities). Access to symbolic knowledge is therefore expected to be based on networks and spill-overs. Social proximity, temporary proximity or international mobility can compensate for a lack of geographical proximity (Gertler, 2008; Martin and Moodysoon, 2011). This is particularly crucial when there is a need for companies in a LPS either to link to places where new creative processes are taking place or to inject in established cultural contexts a new sense of interpretation and new intangible values.

The framework just suggested helps draw connections within the fragmented empirical evidence on the geography of different knowledge bases. In particular, by crisscrossing knowledge characteristics, types of proximity and mechanisms of transmission, it is possible to reach a better understanding of how different knowledge types at different geographical scales can *generate value* for LPSs embarking on sustainable and transformative paths.

[7] Another condition not discussed in this chapter is the *appropriability* that concerns how agents interpret and use the acquired knowledge for extracting value.

3. Geographical scales of competing models in Industry 4.0 technological transformation

Drawing on the conceptual framework presented in the Introduction of this book (Bailey and De Propris, *infra*), it is possible and desirable to include considerations of social and environmental sustainability within and around the pure technical core of the current digital and science driven industrial transformation that goes under the name of *Industry 4.0*. Such inclusion leads to an expanded perspective, so-called *Industry 4.0 plus (I4.0+)*, that implies the generation of alternatives to mainstream models of value creation and distribution, which otherwise would seem to respond deterministically to "natural" efficiency driven arguments. Such efficiency-driven arguments would include the centrality of smart and webbed factories and platforms, the ruling of large and multi-national firms, combining mass-customization of products and a very high intensity of capital in core processes, together with market domination, skill polarization, and the digitally driven deterioration of the citizen's control over choices on local public and common goods.

In contrast, *I4.0+* is based on the idea that the new technologies should and could be addressed to help bringing sustainable growth, a wide mobilization of human capabilities, and prosperity within territories, their populations of firms, workers, families, and between territories. Specifically, the *I4.0+* perspective aims at better understand alternatives in industrial local and regional development that face the current challenges of social, economic and environmental sustainability in models of value creation and distribution.

3.1 Alternative I4.0+ models of value creation and distribution

The alternatives to conventional "efficiency" based models concern various aspects. We refer to Bellandi, De Propris, Santini (2018) for a broader discussion, but we may evoke briefly the core contents of the composite solutions supporting *I4.0+* models as alternatives to the technocratic and centralistic mainstream.

- *Interdependencies around smart networked micro-manufacturing* (SNMM): small factories are able to incorporate new digital based technologies in production processes led by craft skills and care. Small firms managing such factories access international networks of designers, customers and suppliers. Localized pools of SNMM drive a transformation of LPS specialized in manufacturing into product-service systems incorporating territorial servitization (Bellandi and Santini, 2018).
- *Digital participation and distributed service provision*: an open and enlarging set of digital based services would allow a territorial servitization of LPS, strong and non-dependent on large oligopolistic providers. Service concern trade, finance, advertising, labour selection and training, enterprise resource planning and relationship management, collaborative knowledge and innovation networks, etc. (De Maggio et al. 2009). They may develop on local platforms where small firms and citizens are granted digital sovereignty, information freedom, and open access

(Morozov and Bria, 2018). The local counter-balancing power should be inserted within and supported by national and supra-national anti-trust actions.

- *Makers and smart skills*: operative well-trained skills are still crucial in key phases of value chains, if production digital-based technologies are developed not in substitution but in support to professional/creative processes (Barzotto and De Propris, 2018). This would allow to meet customer-specific demand in complex ways and expand smart micro-manufacturing. Examples are the matching of materials of variable quality with multi-purpose tools (I4.0 as well), related quality control, prototypes of new digital based production processes, etc. (Bettiol and Micelli, 2014).
- *Quadruple-helix governance of projects of sustainable socio-economic development*: integrated productive development and innovation projects involve and connect constellations of actors. They include engaged developmental universities, local/regional networks of SMEs non-captured by oligarchies, anchored MNCs forced to relinquish predatory strategies, and civic society, with its more or less local social networks and supporting social innovation towards common goods for a sustainable life (Aoyama and Parthasarathy, 2016).

The contents of alternative manufacturing models under *I4.0+* suggest innovation processes that could promote transformative paths for LPS characterized by a networked plurality of firms and organizations and by manufacturing specializations grown with the previous wave of technological change (Perez, 2009). It is apparent that a wide and coordinated introduction of such contents would imply the access, absorption, and creative combination of different types of knowledge. This would be the basis for paths of accentuated upgrading in those systems.

3.2. Knowledge bases and multi-scalar mechanisms in I4.0+

We apply now the framework presented in Section 2 to the models discussed just above under the *I4.0+* perspective, in order to derive general suggestions on the relations between transfer mechanisms and the multi-scalar setting for knowledge access and combination that drive transformations in LPS. The core of such model, we would suggest, lies in small networked smart manufacturing solutions.[8] Within and around such core, there is a need for the development of digital participation and distributed service provision; the diffusion of neo-maker competences, combining artisan attitudes and digital skills; and the quadruple-helix governance of projects of sustainable socio-economic development.

Our concern now is to understand what the geographical scale of processes of knowledge access and combination for innovation might be both for the mainstream technocratic and centralistic models leading to cyber-physical production organizations and for *alternative distributed model* (inspired to *I4.0+*). In particular,

[8] This concerns also analogous productive solutions outside manufacturing, e.g. with precision agriculture, sustainable tourism, creative industries, personalized welfare, etc. (Crespi et al., 2014).

we want to investigate under what conditions LPS characterized by a networked cluster of independent specialized business organizations can pursue processes of innovation incorporating the alternative model, and by this support paths of sustained upgrading and regional transformation (path renewal or even path creation).

Starting from the productive core, the basic feature that the *alternative distributed model* shares with the centralistic efficiency-driven one is the importance of codified knowledge in terms of digital coding and software development underlining the I4.0 technologies or their applications. R&D on new types of coding and new application to multiple fields of scientific and technological problems pertain obviously to efforts of creation of analytical knowledge. Such efforts are concentrated, though non-exclusively, in few hot high-tech hubs around the word. The results of their efforts may be in principle transmitted in codified form at a distance. However, successful transfer and acquisition of such results require absorptive capacity; in other words, they necessitate pre-existing digital competences internal to users-firms, either to generate new combinations by clinging incoming knowledge with the knowledge bases already present in the firm, or just to adopt new technologies developed elsewhere.

Given the breadth and the speed of the development of new digital technologies, the support of specialized intermediary agents in LPS is also needed. They are knowledge intensive business or service providers (KIBS/KIS) that combine parts of the analytical knowledge with the synthetic knowledge related to features and idiosyncrasies of specific technological, production or organizational fields of firms in the LPS. In certain cases, KIBS/KIS providers combine also significant components of symbolic knowledge, as with design driven innovation (Cooke and Eriksson, 2011). Such combinatorial services may be more or less standardized or customized to the needs of particular users.

Large firms can easily access Industry 4.0 technologies. With their large demand, they rely on the services of national and international KIBS/KIS providers by means of relational contracts and formal networks. Temporary geographical proximity with such international KIBS/KIS providers by means of resident teams is to be expected during the developmental phases or to resolve unexpected shocks in the use; whereas ordinary maintenance and upgrading can be supported at a distance.

Trying to navigate the technological requirements of Industry 4.0 technologies raises very different questions for non-centralized LPS aiming at *alternative distributed production models*. Here we see two main challenges. Firstly, the single business organizations (even local entities of MNCs) included in those LPS ordinarily cannot represent a large demand of service within the portfolio of national or international providers of KIBS/KIS. Secondly, it seems plausible that LPS addressing alternative models to Industry 4.0 should find their competitive advantage in market fields featured by a continuous stream of differentiation, incremental innovations and decentralized creativity, combining personalization of products and artisan ingenuity. Here, synthetic and symbolic knowledge have key functions in terms of value creation, together with an increasing degree of codification and automation in various phases of the value chain. A real servitization of the variable

and differentiated digital components needed by firms belonging to the core productive specializations of the LPS would need geographical proximity and versatility, and the help of various types of mechanisms, also including spill-overs and informal networks. It is a territorial servitization (Lafuente et al., 2017), whereby local KIBS/KIS work in stable contact with the LPS users (Bellandi and Santini, 2018). On the other side, if the LPS is not able to express an effective territorial servitization, digital services may be acquired by LPS users in standardized forms by means of market relations. It would be a situation where the alternative distributed model to Industry 4.0 has reduced chances of success. Large national and international providers of KIBS/KIS may be involved as well in LPS. If there is the possibility to develop digital platforms servicing a critical mass of local users with some specific smart and connectivity-enabling components, then large providers may find profitable to invest in local entities (R&D outsourcing).

Around the productive core, the alternative way needs also to expand from business organizations and networks to the society. Neo-makers, local digital sovereignty, quadruple helix methods of governance express a function played by the contexts of out-of-the factory life that is deeper and larger than just consumption and labor supply. It concerns knowledge access, value creation and value distribution. Giacomo Becattini saw this relation between *in-factory* and *out-of-the-factory life* at work in the development of industrial districts. He pointed to the neo-artisan tendencies opening windows of opportunities in many non-centralized LPS in advanced economies in the second half of the XX century. "*The ever-changing multiplicity of needs demands an exit of capitalist production from the 'factory', and its return to a plenty of 'laboratories' within the society, searching for artisanship, customized service, ties with historical-cultural and environmental sources of peculiar experiences*" (Becattini and Bellandi, 2006, p. 86). And in the words of Sebastiano Brusco: "*Both the 'in-factory' and 'out-factory' spheres contribute directly to shape not only the quality of civil life but also productivity levels and market competitiveness*" (Brusco, 1996, pp. 155-156).

This perspective on the societal side extolled the importance of geographical and social proximity. The local contents of synthetic and symbolic knowledge, that are at the core of DUI modes of learning and innovation (Jensen et al., 2007), were drawing also from the experiences of ordinary life. It was acknowledged, nonetheless, that trans-local networks, local agents of versatile integration, and local centers of services were also needed in order to link the LPS with the development of scientific and technological frontiers (Becattini and Rullani, 1996).

The effective involvement of the societal side is key also in the definition of the distributed non-centralistic approaches to the contemporary digital transformation under the *I4.0+* perspective. The opportunity to combine, at various degrees of breadth and depth, the different knowledge bases is open to more than a few bridging, integrating, gate-keeping business actors. In principle, it may involve a multitude of business, socio-cultural and institutional agents.

What differentiate LPSs' capacity to innovate and take upgrading paths of transformation, is both the effective diffusion of combinatorial competencies and the

collective capability to share a vision on path transformation. The vision may be led by the idea of a key role played by the development of new analytic or synthetic knowledge. However, the vision in itself has necessarily high local and non-local symbolic contents, since it requires a creative exploration of the opportunities offered by Industry 4.0, in which new values and new senses for interpreting society are collectively constructed (Rullani and Rullani, 2018).

Furthermore, such vision should be supported by collective (public and private) investments in specific open and multi-disciplinary platforms for the development of combinatorial capabilities and digitally based innovations. The development of such platforms necessarily rests on analytic/scientific knowledge. Weak combinatorial capabilities would probably force LPS down towards lower paths of transformation, which might plug the LPS within centralistic routes of Industry 4.0, or more generally force it to become subservient to global logics by feeding its economic resources to global chains of production and consumption (Storper, 2009, pp. 155-156).

4. Exemplifications from the Makers project

In this section, we present some applications of the framework developed in the previous sections to the interpretation of the geographic scales of knowledge linkages relevant to path transformation in LPS under *I4.0+* perspectives. Facts and reflections are collected from eight cases discussed within the Reports of the MAKERS project (see Introduction of this volume).[9]

We would partition the eight cases into three sub-sets. The first one includes the transformations of the "paper province" in the Swedish Värmland Region and the Viareggio yachting industry in the Tuscany region (Italy). The second sub-set consists of three textile-based LPSs, in Prato (Tuscany), Borås (in Western Sweden), and St. Gallen, Appenzell and Glarus (in Eastern Switzerland). The third sub-set corresponds to the mechatronic LPS in Veneto (Italy), the automation LPS in Värtmanland (Sweden), and the life sciences LPS in Tuscany. Only the Tuscany life sciences LPS has a strong basis in a metropolitan area (Florence), whereas the Eastern Switzerland LPS is confined within a set of relatively small cities, and it includes traditionally a related variety of sectors around the decreasing textile specialization. All the other LPSs are in reality industrial districts supported by different types of regional innovation systems.

In what follows, we focus in particular and discuss the cases of the first sub-set, that is the traditional medium tech industries (the pulp and paper industry in Värmland; the yachting industry in Viareggio), and their geographical scales, knowledge bases, and path transformation under *I4.0+* perspectives. The cases of the

[9] A cautionary note is needed: the researches on the cases, to which we refer, have not been developed directly for application and test of the interpretative framework illustrated in this chapter. Therefore, some implications concerning the single cases are rather speculative. Nonetheless, we are confident about the robustness of the overall comparative panel.

other two sub-sets will be more shortly discussed to provide some complementary observation at the end of the section.

The pulp and paper industry in Värmland and the yachting industry in Viareggio have developed in the past decades as the main manufacturing specialization of the respective LPS, with competitive advantages grounded into the relation between a strong basis of synthetic knowledge and specific locational factors. Both cases are interesting because such locational factors have been turned in the last decades in a strong source of symbolic knowledge, still combining with local synthetic knowledge, but also attracting the activity of providers of analytic knowledge. Both cases can be taken as examples of alternative I4.0+ models that challenge the narrower definition of Industry 4.0, and allows to look at the geographical scale and knowledge bases of paths to upgraded transformation.

4.1. Combinatorial knowledge bases and multi-scalar mechanisms in the transformation of pulp and paper in Värmland (Sweden)

In this case, the locational factor is represented by the proximity to a large land of forests, an abundance of woods that may be easily treated for pulp extraction, and a tradition of preservation of the natural patrimony. The pulp and paper industry has developed for almost a century, with a strong presence of manufacturing plants and R&D laboratories part of some large national and international companies, together with a population of specialized SMEs, also included those related to forest works.

Chapter 4 by Ramirez (i*nfra*) illustrates the emergence of a path of transformation, from the traditional pulp and paper specialization to a more differentiated and analytic knowledge intensive path, which is called the “forest-based bio-economy” within a plan promoted by a local cluster organization in the last decade. The enduring basis is a multiplicity of nuclei of manufacturing synthetic knowledge, in dialogue with the synthetic knowledge of forest related activities. Crucial manufacturing synthetic knowledge is hosted within the larger plants and accessed thanks to networks and spill-overs at the local level or through technologies partly acquired on external markets. The access to analytical knowledge has been also important both for the absorption and partly for the development of some more capital intensive technologies in the pulp processes, and for an environmental sustainable approach to large scale exploitation of wood resources.

The cluster initiative in the last years has tried to promote the shift to an economy specialized in the production of renewable biological resources, also with the support of digital technologies. In that cluster initiative, a critical role seems to be played by the strategic orientation of national and regional innovation systems, the investments by multinational companies (MNCs) embedded in the local economy, and the role played by technological intermediaries. New analytic knowledge is developed thanks to the presence of R&D laboratories of large MNCs firms. However also networks with local and national universities result supportive in this respect.

The cluster management agency, the national innovation agency, and the international technological intermediaries have been able to elaborate an integrated

vision and strategy that has pulled a wave of investments also from the distant headquarters of the MNCs. This includes the reference to the highly symbolic contents of the "bioeconomy" (combination of the local forest tradition, the green strategy of the national innovation system, and EU programmes). Moreover, it provides an answer to relevant manufacturing problems (e.g. the disposal of industrial waste), with the interaction between traditional synthetic know-how (accessed by local spill-overs, informal networks, hierarchy) and analytic knowledge (accessed by local formal network and the R&D laboratories of large vertically integrated firms that can digitally control all the phases of the production processes). Around the productive core, the cluster initiative includes projects aimed at diffusing digital competences and increasing the capacity of small local ICT services to access the new demand of the forest based bio-economy (Ramirez, *infra*).

All in all, this case shows a virtuous combination of all three knowledge bases, accessed with appropriately different mechanisms at different spatial scales. The LPS seems ready for accomplishing a path transformation that could be seen, if realized, as a case of successful path creation (See table 2).

--- insert TABLE 2 around here ---

4.2. Combinatorial Knowledge bases and multi-scalar mechanisms in the transformation of the luxury yachting industry of Viareggio.

In this second case, the locational factor is represented by the fact that the luxury yachting industry of Viareggio is located adjacent to an important Tuscan seaside touristic attraction, indeed around Viareggio and Forte dei Marmi that associate to the image of high quality recreational products and services.

As detailed in Chapter 6 by Bellandi, De Propris, Santini, Vecciolini (*infra*), the long-run synthetic knowledge base of the yachting system is the artisan know-how in small ship-building. The industry has evolved in the last decades thanks to the international inflow of analytic knowledge, that has allowed the introduction of new advanced materials, constructive solutions, and gadgets in the building of top-end boats for recreational uses. Nowadays, the LPS is specialized in the production of luxury yachts, with a highly sophisticated and price-inelastic demand from wealthy people.

Each luxury yacht is almost a unique piece with unique design, artisanship and sophisticated technology, including solutions absorbing many types of smart and connectivity digital components. Analytical knowledge is accessed in various ways, but a key role is played by the R&D offices of the local shipyards (which correspond to the sectoral headquarters of large national and international companies), by formal networks with research organizations supported by a regional intermediary organization, and by market relations and informal networks with providers of technology at local, national and international scale. However, R&D is mainly aimed at the creation of new symbolic knowledge for improving design, rather than at the development of new analytic knowledge. Furthermore, the realization of each yacht is highly demanding in terms of practical learning and creativity that involved one-off a

large number of specialized SMEs and artisans. This local core of synthetic knowledge is based on reciprocal spill-overs, formal networks with the shipyards, and informal networks with the providers of technology. Small scale and personalized ICT services for the yacht industry are granted by an ICT cluster based in the nearby city of Pisa. Various types of initiatives (local fairs, professional schools, etc.) tend to involve the local citizens in shaping the destiny of the local industry, even if the growth of neo-maker competences seems quite weak, nor quadruple helix projects on this or other related topics are surfacing at the moment. Indeed, the main knowledge input into the LPS comes from the *out-factory* relationships associated with requests and demands raised by the wealthy buyers from around the world, as well as by the skippers employed by the ship owners.

The case of this LPS appears quite unique. Nonetheless, the luxury yachts industry may be seen as an exemplification of the extreme personalization that might characterise top end and niche industries within the *I4.0+* model. The uniqueness of each product, the continuous introduction of new solutions and the adoption of the latest technologies make it difficult to classify what path the LPS is following or can follow. Perhaps it points to a class of paths of "continuous" renewal, where the creativity that drives personalization may become, in subsequent steps, a source of inspiration for part of the local community to re-use the acquired technologies and develop other related business or civic services. This case is led by the development of symbolic and synthetic knowledge and the absorption of analytic knowledge (See Table 3). In particular, symbolic knowledge has strong local roots, but it demands multi-scale flows and mechanisms of creation and image-building, combined with the absorption of new analytic and synthetic knowledge. Perhaps the local structure would not support local path creation, but the multi-scalar actors involved in the realization of the highly sophisticated unique products which are present at local level could favour new value chains and path creation in other places (Bellandi, De Propris, Vecciolini, *infra*; Bailey, *infra*).

--- insert TABLE 3 around here ---

4.3. Other cases from the Makers project

We come now to the other cases, to extract some supportive facts and final qualifications. The textile cases[10] illustrate *transformation paths based on strong synthetic knowledge* as they face the pressure of contemporary challenges. In all the three cases, symbolic knowledge has acquired a key role, playing nonetheless partially different functions. In the Prato textile district, the image of creativity and quality of *made in Italy* is applied to the synthetic knowledge-based capability to produce rapidly an open and variable range of fabrics, in very small batch (i.e. with a high degree of personalization and some help given by digital technologies). Here,

[10] Bellandi et al, (*infra*) on Prato; MAKERS Report by E.Santini et al. including the case of Eastern Switzerland; Chaminade et al. (2018) on Borås.

symbolic knowledge combines directly into strategies of high personalization of products, and the variety of mechanisms for accessing and absorbing new analytic knowledge is still quite low. In the Borås textile district, a strong governance and innovation system at regional and national levels has promoted a vision that facilitated the absorption of new global analytic knowledge for the development and production of high-tech textile products. Symbolic knowledge seems to play a role in supporting the strategic convergence around a collective strategy of analytic knowledge intensification, helped by multi-scale mechanisms and integration. In the Eastern Switzerland district of embroidery and textile machines, a local system supporting innovation and some civic initiatives, coupled with the presence of local diversified research and manufacturing capabilities, also networked at national and international scales, helped combine the synthetic knowledge basis with the creation of new symbolic and analytic knowledge. In this case, symbolic knowledge apparently plays both roles (personalization and vision).

From such cases, it emerges a confirmation of some aspects detected in the first sub-set. Firstly, the high personalization of products demands the guidance of symbolic knowledge coupled with synthetic knowledge. Secondly, a greater opportunity for radical innovation and path creation seems to demand the guidance of analytic knowledge (accessed in a multi-scalar setting) coupled to a subservient but necessary role of symbolic knowledge. In all cases, the local access to synthetic knowledge cannot be dispensed in LPS that seem to evoke alternative *I4.0+ models*. However, in the stronger cases, also the reproduction and creation of synthetic knowledge is an open field of local converge of multi-scale strategies.

Finally, the third sub-set includes cases characterized by the greatest *use of analytic knowledge.*[11] Even for these, although any path of upgraded transformation depends crucially on access and adoption of analytic knowledge, the extent and depth of the transformation seems related not only to the degree of local capabilities related to analytic knowledge. In particular, paths consistent with the alternative *I4.0+* models, like in Värtmanland, require - beyond the presence of strong local pools of synthetic knowledge - an important access to symbolic knowledge for various creative and absorptive functions and at different geographical scales.

5. Conclusions and further research

The previous discussion linking knowledge bases, multi-scalarity and transformation of LPSs brings some interesting insights into policies (particularly at regional level) sustaining LPSs. *Firstly*, regional policies do not necessarily have to ensure that all three knowledge bases (synthetic, analytic and symbolic) are co-located in the same LPS. Contrary to what has often been argued in the literature, firms and other innovative organizations could access different knowledge even from distant

[11] Corò and Volpe (*infra*) on the Veneto mechatronic LPS and the automation LPS in Värtmanland. For the life sciences LPS in Tuscany we refer to the MAKERS Report by P. Ramirez .

locations. Regional policies aiming at strengthening LPSs need therefore to go hand in hand with more general policies supporting the use of mechanisms to access knowledge at other geographical scales. Which mechanisms are more adequate depends strongly on the type of knowledge base, the capabilities of the firms located in the region, and conditions to access knowledge. It depends also on which type of model of path transformation is pursued. In particular, and in relation to the challenges of Industry 4.0, it depends on the prevalent vision (e.g. if centralistic & technocratic or non-centralistic & distributed) informing public policies and private strategies. *Secondly*, our framework could help extend policies to the consideration of why two firms in the same industry and with similar levels of innovativeness − one located in a knowledge hub and the other one located in a peripheral region − may portray very different configurations.

This paper has some limitations. Firstly, applying a multi-scale framework to knowledge bases, which brings in knowledge characteristics and meso- and micro-conditions, would require data that are beyond what is currently available. In the short term, dedicated firm-based surveys or case studies in different LPS around the world could provide a starting point to conduct empirical analysis based on the proposed framework. Secondly, based on the premises that combinatorial knowledge creating processes involves sourcing of knowledge at different geographical scales, our focus has been on theorizing when and how these multi-scale knowledge-sourcing processes will take place. Admittedly, while the sourcing of knowledge is paramount for innovation, it is only one part of the combinatorial knowledge base processes. Knowledge acquired externally needs to be further processed internally, inside both the singles firms and related organizations and among them within LPS. In other words, while this paper provides some insights on how different knowledge bases are *sourced* using different mechanisms at different scales, it does not discuss how the firm *combines* them into knew knowledge. Other chapters of this book take more directly this point, also considering in depth some of the cases referred to above within the MAKERS project.

Acknowledgements: We gratefully acknowledge the support by the EU Horizon 2020 project MAKERS, which is a Research and Innovation Staff Exchange under the Marie Sklodowska-Curie Actions, grant agreement number 691192 Conferences. All errors remain exclusively of the authors.

References

Aoyama, Y., and Parthasarathy, B. 2016. *The Rise of the Hybrid Domain. Collaborative Governance for Social Innovation*. Cheltehham: Edward Elgar.

Asheim, B.T., and Coenen, L. 2005. Knowledge bases and regional innovation systems. Comparing Nordic clusters. *Research Policy*, 34(8), 1173–1190.

Asheim, B.T. and Gertler, M.S.. 2005. The Geography of Innovation: Regional Innovation Systems. In *The Oxford handbook of innovation*, ed. J. Fagerberg, Mowery, D. and Nelson, R. (eds.), 291-317. Oxford: Oxford University Press.

Asheim, B., Grillitsch, M. and Trippl, M. 2017. Introduction: Combinatorial Knowledge Bases, Regional Innovation, and Development Dynamics. *Economic Geography*, 93 (5), 429-435.

Barzotto, M. and De Propris, L. (2018). Skill up: smart work, occupational mix and regional productivity. *Journal of Economic Geography*, in press, https://doi.org/10.1093/jeg/lby050

Bathelt, H., A., Malmberg, A., Maskell, P., 2004. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28 (1), 31-56.

Becattini G. and Bellandi, M. 2006. Distretti industriali: un paradigma socio-economico" in Fortis, M. and Quadrio Curzio, A. (a cura di), *Industria e distretti. Un paradigma di perdurante competitività italiana*. Bologna: Il Mulino.

Becattini G. and Rullani E. 1996. Local systems and global connections: The role of knowledge. In Cossentino, F., Pyke, F., and Sengenberger, W. (eds) *Local and Regional Response to Global Pressure: The Case of Italy and its Industrial Districts*. Geneva: International Institute for Labour Studies.

Bellandi, M., De Propris, L., and Santini, E. 2018. Industry 4.0+ challenges to local productive systems and place-based integrated industrial policies. Mimeo. In print for an edited volume.

Bellandi, M. and Santini, E. 2018. Territorial servitization and new local productive configurations: the case of the textile industrial district of Prato. *Regional Studies*, in press. doi.org/10.1080/00343404.2018.1474193.

Bettiol, M., and Micelli, S. 2013. The hidden side of design: The relevance of artisanship. Design/Issues, 30(1), 7–18.

Boschma, R. 2005. Proximity and Innovation: A Critical Assessment. *Regional Studies,* 39 (1), 61-74.

Brusco, S. 1996. Global systems and local systems. In Cossentino, F., Pyke, F., and Sengenberger, W. (eds) *Local and Regional Response to Global Pressure: The Case of Italy and its Industrial Districts*. Geneva: International Institute for Labour Studies.

Chaminade C., Bellandi M., Plechero, M., and Santini, E., 2017. Paper on the role of RIS/NIS and knowledge transfer on manufacturing upgrading. MAKERS Deliverable 2.2. http://www.makers-rise.org/publications/.

Chaminade C., Bellandi M., Plechero, M. and Santini, E., 2018. Path renewal and creation in specialized regional innovation systems. A comparative analysis of two textile districts in Italy and Sweden. Paper presented at the Workshop: Rethinking clusters: critical issues and new trajectories of cluster research, University of Florence, Italy; May 3rd and 4th.

Cooke, P. and Eriksson, A. 2011. Design-driven regional innovation. In Cooke, P., Asheim, B., Boschma, R., Martin, R., Schwartz, D., and Tödtling, F. (eds.), *Handbook of Regional Innovation and Growth*, Cheltenham: Edward Elgar.

Corradini, C. and De Propris, L. (2015). Technological diversification and new innovators in European regions: evidence from patent data. *Environment and Planning A: Economy and Space*, 47 (10), 2170-2186

Crespi, G., Fernandez-Arias, E., and Stein, E. H. (Eds.). 2014. *Rethinking productive development: Sound policies and institutions for economic transformation*. Inter-American Development Bank (IDB) series. New York: Palgrave Macmillan.

De Maggio, M., Gloor, P.A., and Passiante, G. 2009. Collaborative innovation networks, virtual communities and geographical clustering. *International Journal of Innovation and Regional Development*, 1 (4), 387 – 404.

Gertler, M. 2008. Buzz Without Being There? Communities of Practice in Context. In Amin, A. and Roberts, J. (eds.), *Community, Economic Creativity, and Organization*, Oxford: Oxford University Press, 203-227.

Giuliani, E. 2007. The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of Economic Geography* , 7 (2), 139-168.

Grillitsch, M., Asheim, B.T and Trippl, M. 2018. Unrelated knowledge combinations: the unexplored potential for regional industrial path development. *Cambridge Journal of Regions, Economy and Society*. In press doi.org/10.1093/cjres/rsy012.

Grillitsch, M, Martin, R. and Srholec, M. 2017. Knowledge Base Combinations and Innovation Performance in Swedish Regions. *Economic Geography*, 93 (5), 458-479.

Grillitsch, M. and Trippl, M. 2014. Combining Knowledge from Different Sources, Channels and Geographical Scales. *European Planning Studies*, 22 (11), 2305-2325.

Herstad, S.J., Aslesen H.W. and Ebersberger, B. 2014. On industrial knowledge bases, commercial opportunities and global innovation network linkages. *Research Policy* 43 (3), 495-504.

Isaksen A. and Trippl M. 2016. Exogenously led and policy-supported new path development in peripheral regions: Analytical and synthetic routes. *Economic Geography*, 93 (5), 436-457.

Jensen, M.B, Johnson, B. , Lorenz, E. and Lundvall, B. 2007. Forms of knowledge and modes of innovation. *Research Policy*, 36 (5), , 680-693.

Kafouros, M.I.,; Buckley, P.J. and Clegg, J. 2012. The effects of global knowledge reservoirs on the productivity of multinational enterprises: The role of international depth and breadth. *Research Policy* 41 (5), 848-861.

Lafuente, E., Vaillant, Y., and Vendrell-Herrero, 2017. Territorial servitization: Exploring the virtuous circle connecting knowledge-intensive services and new manufacturing businesses. *International Journal of Production Economics*, 192, 19-28.

Liu, J., Chaminade, C. and Asheim, B. 2013. The Geography and Structure of Global Innovation Networks: A Knowledge Base Perspective. *European Planning Studies* 21 (9), 1456-1473.

Manniche, J., Moodysson, J. and Testa, S. 2017. Combinatorial Knowledge Bases: An Integrative and Dynamic Approach to Innovation Studies. *Economic Geography*, 93 (5), 480-499.

Martin, R. and Moodysson, J. 2011. Innovation in Symbolic Industries: The Geography and Organization of Knowledge Sourcing. *European Planning Studies* 19 (7), 1183-1203.

Martin, R. and Moodysson, J. 2013. Comparing knowledge bases: on the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden. *European Urban and Regional Studies* 20 (2),170-187.

Martin, R., Aslesen, H.W., Grillitsch, M., Herstad, S.J., 2018. Regional innovation systems and global flows of knowledge. In Isaksen A., Martin R., Trippl M. (eds), *New Avenues for Regional Innovation Systems-Theoretical Advances, Empirical Cases and Policy Lessons*. Cham: Springer, 127-147.

Martin, X. and Salomon, R. 2003. Knowledge transfer capacity and its implications for the theory of the multinational corporation. *Journal of International Business Studies*, 34 (4), 356-373.

Mattes, J. 2012. Dimensions of proximity and knowledge bases: innovation between spatial and non-spatial factors. *Regional Studies* 46 (8),1085-1099.

Morozov, E., and Bria, F. (2018), *Rethinking the smart city. Democratizing Urban Technology*. New York: Rosa Luxemburg Stiftung, New York Office.

OECD 2016. *Science, Technology and Innovation Outlook 2016: Megatrends affecting science, technology and innovation*. Paris: OECD Publishing.

Perez, C. (2009). Technological revolutions and techno-economic paradigms. *Cambridge Journal of Economics*, 34 (1), 185–202

Powell, W. 1990. Neither market nor hierarchy. *Research in Organizational Behaviour* 12, 295-336.

Rosenkopf, L. and Almeida, P. 2003. Overcoming local search through alliances and mobility. *Management Science*, 49 (6), 751-766.

Rullani F., and Rullani, E., 2018. *Dentro La rivoluzione digitale. Per una nuova cultura dell'impresa e del management.* Torino: Giappichelli Editore.

Song, J., Almeida P. and Wu, G. 2003. Learning–by–Hiring: When Is Mobility More Likely to Facilitate Interfirm Knowledge Transfer? *Management Science*, 49 (4), 351-365.

Storper, 2009. The economics of context, location and trade: Another great transformation? In G. Becattini, M. Bellandi and L. De Propris (Eds.), *A Handbook of industrial Districts*. Cheltenham: Edward Elgar.

Strambach, S. 2017. Combining Knowledge Bases in Transnational Sustainability Innovation: Microdynamics and Institutional Change, *Economic Geography*, 93 (5), 500-526.

Strambach, S. and Klement, B. 2012. Cumulative and Combinatorial Micro-dynamics of Knowledge: The Role of Space and Place in Knowledge Integration. *European Planning Studies* 20 (11),1843-1866.

Torre, A. 2008. On the role played by temporary geographical proximity in knowledge transmission. *Regional Studies* 42 (6), 869-889.

Trippl, M., Grillitsch, M., and Isaksen, A., 2017. Exogenous Sources of Regional Industrial Change: Attraction and Absorption of Non-Local Knowledge for New Path Development. *Progress in Human Geography*, 42 (5), 687-705.

Trippl, M., Tödtling, F. and Lengauer, L. 2009. Knowledge sourcing beyond buzz and pipelines: evidence from the Vienna software sector. *Economic Geography*, 85 (4), 443-462.

World Bank 2017. *Trouble in the Making? The Future of Manufacturing-Led Development*. Washington: World Bank Publications.

Table 1. Some key mechanisms for firms in LPS to access different Knowledge bases in a multi-scalar setting

Mechanism / Knowledge base	**Markets (Within LPS)**	**Markets (Beyond LPS)**	**Spillovers (Within LPS)**	**Spillovers (Beyond LPS)**	**Networks (Within LPS)**	**Networks (Beyond LPS)**	**Hierarchies (Within LPS)**	**Hierarchies (Beyond LPS)**
Analytical	Trade (e.g. patents)	Trade (e.g. patents)			R&D collaboration (e.g. research consortium)	Domestic/International R&D collaboration, but necessary some cognitive/organizational proximity) **(this can be key for knowledge creation**)		
Synthetic	Trade (market technologies/goods for codified aspects of engineering process)	Trade (market technologies/goods for codified aspects of engineering process)	Local mobility of human resources and face to face interactions	International mobility, temporary geographical proximity	Networks (often informal)	Domestic networks (also informal, but institutional proximity is necessary)	R&D offshoring from MNCs in loco (this **can be key for knowledge renewal)**	International R&D offshoring (e.g. in specialized hubs) (this **can be key for knowledge renewal)**
Symbolic			Local mobility of human resources	National/international recruitments of skilled labour	Networking within local community (e.g. community of practice)	International communities(e.g. epistemic communities, some social proximity is necessary) **(this can be key for new sense making)**		

Source: elaboration by the authors

Table 2. MAKERS cases: Combination of knowledge bases in a multi-scalar setting in the pulp and paper industry in Värmland

	Path creation towards I4.0 "PLUS": use of combined analytical, synthetic and symbolic knowledge at different geographical levels transforming a paper and pulp specialized LPS to Forest based bio-economy LPS							
	Markets (Within LPS)	**Markets (Beyond LPS)**	**Spillovers (Within LPS)**	**Spillovers (Beyond LPS)**	**Networks (Within LPS)**	**Networks (Beyond LPS)**	**Hierarchies (Within LPS)**	**Hierarchies (Beyond LPS)**
Analytical		Digital technologies in the pulp processes and aimed at sustainable environment			R&D collaboration with large firms; Networks with local universities	Networks with national universities		
Synthetic		Market technologies related to synthetic processes	Spillover from domestic/international MNCs within Pulp industry located in LPS		Interactions at local level between traditional and forest related activities (mediated by cluster organization)	Bridge role in international networks played by local MNCs and technological intermediaries	R&D offshoring from MNC located in LPS	
Symbolic					Bio-economy concept: shared value at local level (emerging from a cluster initiative)	Bio-economy concept: shared value with national and international stakeholders		

Source: elaboration by the authors on MAKERS cases, www.makers-rise.org

Table 3. MAKERS cases: Combination of knowledge bases in a multi-scalar setting: The luxury yachting industry

	Continuous path renewal driven by extreme personalization: development of new symbolic and synthetic knowledge with absorption of analytic knowledge							
	Markets (Within LPS)	**Markets (Beyond LPS)**	**Spillovers (Within LPS)**	**Spillovers (Beyond LPS)**	**Networks (Within LPS)**	**Networks (Beyond LPS)**	**Hierarchies (Within LPS)**	**Hierarchies (Beyond LPS)**
Analytical		Digital technologies advances material, new constructive solutions			Networks with research organizations; networks with provider of technologies (weak R&D)	National and International networks with providers of technologies (weak R&D)		
Synthetic			Local companies reciprocal spillover		Formal networks within the shipyards; Informal networks with providers of technologies			
Symbolic					R&D collaborations for new symbolic/design knowledge	R&D collaborations for new symbolic/design knowledge		

Source: elaboration by the authors on MAKERS cases, www.makers-rise.org