

From knowledge broker to solution provider in the Industry 4.0 setting: the innovation path of a small consulting firm

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Abstract

Purpose – This study aims to explore the resource development process implemented by a small consulting firm, active in a traditional industrial context, pursuing the innovation path to develop solutions within the Industry 4.0 (I4.0) domain.

Design/methodology/approach – This study undertakes a single qualitative case study of Sinergia, an Italian innovative small consulting firm. The case study is analyzed through critical events and adopting the 4R model, developed within the industrial marketing and purchasing (IMP) approach.

Findings – The analysis highlights a transition from knowledge broker to solution provider, based on a process of networking, with a relevant strategizing effort, and of assembling internal, external and shared resources. Three patterns in the evolution of the company's innovation path emerge: resource-oriented networking, hybrid resource development and resource assembly.

Originality/value – The empirical study provides novel empirical evidence over localized innovation processes in I4.0 by exploring the innovation path pursued by a small consulting firm in connection with the local business. The study represents a theoretical development in terms of the 4R model as it suggests the need to further conceptualize the category of technical resources – including products and facilities – in the increasingly complex I4.0 domain and provides insights on the changing role of actors in networks underpinned by emerging resource structures.

Keywords Industry 4.0, Consulting firms, SMEs, Resources, Innovation

Paper type Research paper

1. Introduction

The industrial landscape has changed deeply in the past few years due to the digital transformation known as Industry 4.0 (I4.0) (Ghobakhloo, 2020; Pereira and Romero, 2017). I4.0, defined as the “fourth stage of industrialization” (Kagermann *et al.*, 2013, p. 13), is changing the outlook of manufacturing and services industries by impacting both the organization of production processes and the business models (De Backer and Flaig, 2017).

I4.0 represents one of the main emerging technological and organizational challenges for firms of different sizes and sectors coping with its multifaceted aspects (Bellandi *et al.*, 2019; Matthyssens, 2019). On the one hand, I4.0 implies substantial investments in equipment and technologies, the development of competences and an organizational context ready to support the transformation process (Agostini and Nosella, 2019; Frank *et al.*, 2019). On the other hand, I4.0 is related to specific innovation policies aimed at reinforcing the competitiveness of

firms, mobilizing a variety of actors – business, academia, institutions and knowledge providers (Ciffolilli and Muscio, 2018) – to innovate collaboratively in a logic of open innovation (Schepis *et al.*, 2021), in which value creation occurs through combining resources and capabilities across organizational boundaries. Recent contributions have placed attention on the business and institutional context of I4.0 diffusion in terms of public support and knowledge dissemination processes (Hervas-Oliver *et al.*, 2019; Pagano *et al.*, 2021).

In this evolving context, the perspective of providers of I4.0 solutions has surprisingly received limited attention. Most of the existing research has been concerned with the implementation of I4.0 by industrial firms in both high-tech and traditional sectors. Less emphasis has been placed on the

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role played by consulting firms, whose contribution and support is key for promoting advanced digitalization processes in customer firms, often as “first movers” (Trotta and Garengo, 2019). The value of the consultancy market in Europe reached \$45bn in 2019. In 2020, COVID-19 had an impact on this sector, negatively affecting the established trend of turnover growth (FEACO, 2020); however, consulting in “Technology and Operations” have kept growing in absolute and relative terms driven by the strong involvement of consultancy firms in supporting digitalization processes. Within this scenario, according to sectoral reports, large information technology (IT) consulting firms detain resources and capabilities to develop and provide services in the I4.0 domain (McKinsey & Company, 2016), while medium/small-sized consulting companies often do not have the required expertise (FEACO, 2020). This creates an emerging “digital divide” among large and small consulting companies engaging with advanced digital projects, such as in the I4.0 setting. Thus, small consulting firms are called upon for developing new skills and know-how both on the business and on the IT side (Bensberg et al., 2019; Oesterle et al., 2020; Benitez et al., 2021) to provide I4.0 solutions for their customers, which are often small and medium sized enterprises (SMEs) with limited technological and organizational resources. SMEs tend to involve small – rather than large – consulting firms in digitalization projects, as they offer more customized solutions and adequate assistance in terms of training and continuous feedback. For example, in a country characterized by the prevalence of small firms as Italy, there are more than 23,000 small consulting firms, with 20,000 of them employing fewer than three persons (FEACO, 2020) but representing up to 30% of the sector’s turnover (Assoconsult, 2022). Therefore, relationships between small-medium size consulting firms and their mainly small customer firms have a key role in the dissemination and adoption of advanced digital solutions.

Hence, this paper aims to provide a better understanding of the role of small solution providers in the I4.0 context in terms of their “transition” to become valuable partners for their customer firms. For small consulting firms engaging in I4.0 solutions implies both detaining state-of-the-art knowledge and effectively networking with specialist technology providers. This means being able to develop and assemble I4.0-related resources in complex projects as a result of an innovation-oriented transition path. The idea of an innovation path reflects the spatial and temporal dimension of innovation (Purchase et al., 2016) and the “muddling through” characterizing such processes (Makkonen et al., 2012). The paper analyses in-depth this process – thus far largely unexplored – and addresses the following research question (RQ):

RQ. How do small consulting firms develop resources in their innovation path in the I4.0 domain?

We answer this RQ by undertaking an explorative case study concerning the consulting firm *Sinergia*, a small-sized consulting company based in Center Italy and providing services on European Projects, Systems for Managerial Control and Risk Management and Lean Technology (LT). The company is based within a region characterized by a dense network of SMEs active in various industrial districts – furniture, yachts, footwear – and operating in both high-tech

and traditional industrial sectors. *Sinergia* has been chosen to provide the perspective of a service and solution provider operating in a context characterized by firms active in traditional industries, in an area where over the years, an effort has been made by the local government for promoting the technological and digital upgrading, as the region has been among the first in Italy to adopt the S3 strategy (Eklinder-Frick et al., 2020a).

The case analysis follows a longitudinal approach (Halinen and Törnroos, 2005) to highlight the main events (Purchase et al., 2016) occurring in identified temporal phases (Quintens and Matthyssens, 2010) and the development of resources related to innovation in the I4.0 context.

The empirical analysis relies on the Industrial Marketing and Purchasing (IMP) approach as the main conceptual and analytical framework and, notably, on the 4Rs model as it can guide research over resource development processes (Baraldi et al., 2012; Bocconcelli et al., 2020). Specifically, it is argued that the 4Rs model offers a useful perspective on three different grounds. First, it helps in understanding the combining process overtime of different resources in the development of new offerings; second, it allows for assessing complementary changes in the technological base and in the organizational setting supporting the innovation process; third, it conceives “business relationships” as resources and thus allows to explore the nature of multiple networks where the focal company is embedded (Håkansson and Waluszewski, 2002).

The paper is structured in five main sections, besides the introduction. In Section 2, we analyze the emergence of I4.0 as a policy and management concept and the main technological and organizational challenges for firms, with a focus on SMEs and IT providers; then, the resource interaction approach in innovation processes is discussed. Section 3 presents the methodology adopted in the study and the analytical framework used for analyzing data. Section 4 concerns the case study analysis, focusing on the different phases of *Sinergia*’s innovation path for I4.0. Section 5 discusses the main results of the empirical analysis and answers the RQ. Section 6 draws conceptual, managerial and policy implications, and outlines the main limitations of the study along with main future developments of the research.

2. Background

2.1 Industry 4.0, SMEs and IT providers

The recent debate – in academia and the business world – about innovation in industrial sectors is shaped by the diffusion of I4.0 model of organization of production processes, involving innovative and pervasive advanced digital technologies in a variety of technological fields (Roblek et al., 2016). The concept of I4.0 “is often referred to as the fourth industrial revolution and embraces a set of technological advances that are having a high impact in the current industrial landscape” (Pereira and Romero, 2017, p. 1208) or the “comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the Internet with conventional industry” (German Chancellor Angela Merkel – Organization for Economic Co-operation and Development, 19 February 2014).

I4.0 represents both one of the main emerging technological and organizational challenges for SMEs (Moeuf *et al.*, 2020; Müller *et al.*, 2018), and a key area for investment by the European Union and various governments in Europe (Smit, 2016) that have promoted many policy measures to provide financial support and enhance knowledge transfer mechanisms to the benefit of SMEs operating in both traditional and high-tech sectors (Muscio and Ciffolilli, 2020). SMEs are, in fact, affected by limited resources in terms of skills, funding (Matt *et al.*, 2020; Müller and Däschle, 2018) and knowledge (Radas and Bozic, 2012; Marcelino-Sádaba *et al.*, 2014; Arbussa *et al.*, 2017) that are essential to transform inventions into products/solutions or processes (Salerno *et al.*, 2015). Therefore, facilitating innovation in SMEs has become a cornerstone of policy initiatives to stimulate economic development at local, regional and even national levels (Jones and Tilley, 2003).

As technology becomes so complex, as in the case of I4.0, that it cannot be managed by a single firm, and relevant knowledge is distributed among various firms and institutions (Brunswicker and van de Vrande, 2014), collaboration among firms and between firms and institutions is acknowledged as a key factor for success (Lee *et al.*, 2010). A stream of studies indeed has started to explore the role of supporting actors, able to provide a contribution in terms of I4.0 knowledge dissemination and transfer. A few existing studies have attempted to understand the role of public organizations such as local institutions, universities, formal clusters and innovation agencies, placing emphasis on their role as promoters of awareness about the value of I4.0 technologies and as knowledge providers and/or brokers, even though with mix effects due to the complexity of I4.0 technologies and the fragmentation of the overall institutional effort (Hervas-Oliver *et al.*, 2019; Götz and Jankowska, 2017; Pagano *et al.*, 2021). It is apparent that the development of the I4.0 and the growing recognition of universities as drivers of regional development (Benneworth and Hospers, 2007) have led to a growing awareness of the role of these nonbusiness actors not only as producers of knowledge and innovation (Wolfe, 2005) but also as one of the main agents of economic growth. Thus, cooperation between firms, especially SMEs, and universities became essential to foster innovation (Babkin *et al.*, 2013).

While there is a growing attention on “user” industrial firms – in terms of technology selection, implementation processes and effects on relationships with suppliers and customers (Szalavetz, 2019; Schroeder *et al.*, 2019; da Silva *et al.*, 2018; Galvani and Bocconcelli, 2022) – and on the role played by universities (Onar *et al.*, 2018) and technology centers (Müller and Hopf, 2017), less attention has been paid to the “provider” side and notably to I4.0 business partners such as IT and consulting firms. Service and solution providers within the I4.0 paradigm represent companies that offer “complete solutions in which products and services are integrated” (Müller and Däschle, 2018, p. 263), i.e. the offering side. Studies have contributed to the definition of architectural frameworks that can support the creation of supplier solutions, sometimes of open-source nature, within the I4.0 paradigm (Batista *et al.*, 2017). It is well-known in the innovation literature the role of consulting firms in partnering with local manufacturing firms to spread innovations in local networks, including IT-based knowledge and resources (Seclen

and Barrutia, 2018). However, in the case of I4.0, the ability of consulting firms in providing adequate consulting services should not be taken for granted; on the contrary, it could be argued that consulting firms – especially those having a small-medium size – could face a tough challenge while undertaking I4.0 projects, which might require a complex development process in terms of adequate technological and organizational resources. Indeed, the implementation of I4.0 requires meeting several requirements in terms of data analysis, organizational structures and integration, communication and cooperation between business processes (Brousell *et al.*, 2014; Macaulay *et al.*, 2015). We, thus, argue that in-depth research is needed for understanding how small consulting firms have engaged in their resource development processes for becoming recognized I4.0 providers.

2.2 A resource interaction approach on innovation processes

Firms are increasingly relying on interorganizational interaction to pursue innovation processes (Lind, 2015; Gadde and Lind, 2016). When it comes to highly complex knowledge, such as in the I4.0 setting, actors often engage in time-limited projects, partnerships or programs involving external partners and external sources of knowledge (Schumacher *et al.*, 2016). Indeed, external resources and partners are key within innovation processes and can be accessed through interorganizational relationships with other firms but also with research centers, universities, consulting agencies (Lind *et al.*, 2012).

Recently, within IMP, there has been an increasing focus on projects dealing with innovation and digitalization (i.e. Rubach *et al.*, 2017; Håkansson and Waluszewski, 2018; Eklinder-Frick *et al.*, 2020b). Studies have shown the importance of managing organizational intangible aspects, such as competences and organizational practices when dealing with changes brought up by technological development projects (Fremont *et al.*, 2019). Innovation processes require spanning between and beyond firms’ and network boundaries; the stimulation of innovative processes is spurred by interactions and overlaps between innovation network initiatives and previously established industrial networks (Rubach *et al.*, 2017). The major forces behind innovation projects are represented by “the heaviness of related resources, their spatial characteristics and their journey” (Håkansson and Waluszewski, 2018, p. 259).

In line with previous IMP studies (Gadde and Lind, 2016; La Rocca and Snehota, 2014; Hoholm and Olsen, 2012), we argue that the networked nature of innovation processes and projects can be understood in terms of resource interaction and development. The link between innovation processes and resources has been explicitly touched on by La Rocca and Snehota (2014), who argue that innovation processes in the forms of new solutions and offerings are developed by means of combining and recombining resources. Indeed, innovation is generated through interaction between specific companies’ constellations of existing sociomaterial resources (Håkansson and Waluszewski, 2018; Eklinder-Frick and Åge, 2017; Gadde and Lind, 2016). Resource interaction has been defined within IMP as “the processes of combination, recombination, and codevelopment of resources that happen through the interaction among organizations” (Baraldi *et al.*, 2012, p. 266).

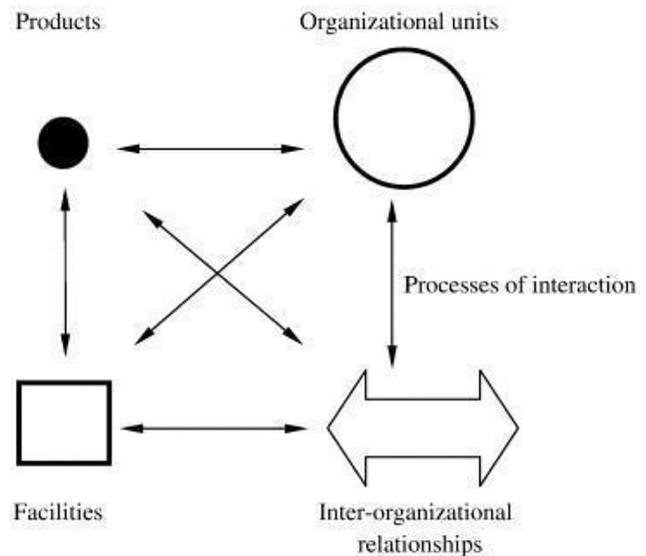
Indeed, by engaging in innovation processes, firms need to introduce new resources and competences, which affect existing interfaces and must, in turn, become embedded with them (Håkansson and Waluszewski, 2018). Resource embeddedness requires creating new resource structures and could lead to clashes with established business models (Eklinder-Frick et al., 2020b). Arising frictions might be mitigated by developing partnerships and ensuring continuity across projects (Crespin-Mazet et al., 2015).

The 4 R model, developed within the Resource Interaction Approach, appears a suitable lens for investigating innovation processes (Baraldi and Ingemansson, 2013; Baraldi et al., 2012) since, as mentioned above, projects provide the context for the dynamic combination and interaction of resources (Baraldi, 2008; Lind et al., 2012) and because actors taking part in interorganizational projects have different goals that need to match to engage in effective resource combining (Corsaro and Cantù, 2015). More in detail, IMP studies have used the 4 R model to classify, map and analyze the process of resource interaction (Baraldi et al., 2012), the variability of resources in use by actors in innovation processes and the relevance of leveraging resources in the network (Ostendorf et al., 2014).

Within the 4 R model, resource development processes are analyzed as the interplay between physical (or technical) resources and organizational (or social) resources: physical resources (i.e. *products* and *facilities*) have material properties; organizational/social resources (i.e. *business units* and *business relationships*) are characterized by social features and display intangible characteristics (Håkansson and Waluszewski, 2002). Products can be described as artifacts, goods and services. Products, according to the 4 R model, are the result of historical and future interaction patterns (Strömsten and Waluszewski, 2012). Facilities concerned interdependent technical resources and equipment (plants, logistics, infrastructures, information systems) used to create products. Products and facilities are conceptually connected since facilities are needed to produce products (Waluszewski and Wagrell, 2013). Business units include individuals, internal units or firms and represent key resources encompassing various intangible elements, such as procedures, skills, experience, knowledge, trust, identity and reputation. The interaction among units benefits the involved parties, which gain imprints from interaction and develop specific social features (Håkansson and Waluszewski, 2002). The last class of resources is business relationships, that is, the ties and links created by actors in interaction and mobilized by organizational unit resources (Baraldi et al., 2012). Figure 1 depicts the original 4 R model (Baraldi et al., 2012) as developed within IMP.

Understanding how internal and external resources are combined and recombined represents a central issue in the development of I4.0 enabling technologies. Indeed, digitalization implies extensive reconfiguration of products creating considerable risk for suppliers who may not have control over critical external resources and who tend to link each other through “weakly manageable” nonhierarchical relationships, fostering the development of emerging business networks (Schroeder et al., 2019; Davis and Cobb, 2010; Agrifoglio et al., 2017). For the aim of this paper, namely, exploring resource development processes implemented by

Figure 1 The 4R model



consulting firms active in I4.0 projects, the 4 R model is used to guide the research on three grounds:

- 1 to help understand the combining process of different pieces of knowledge and technologies in the development of new offerings;
- 2 to allow for assessing complementary changes in the organizational setting supporting the innovation process; and
- 3 to conceive “business relationships” as resources and thus allows to explore the nature of multiple networks where the focal company is embedded (Håkansson and Waluszewski, 2002).

3. Methodology

This research aims to explore the resource development processes implemented by small consulting firms trying to innovate in developing solutions related to the enabling technologies of I4.0. Given the explorative nature of the *RQ* and in line with existing studies on resource development processes for innovation (Håkansson and Waluszewski, 2002; Baraldi et al., 2012), this research follows a qualitative approach and is based on a single case study, following an abductive approach for coding information and elaborating results (Yin, 2003; Dubois and Gadde, 2002). The single case study method is deemed suitable to both catches the complexity related to the process of development of the focal company while trying to evolve within a fast changing and challenging scenario (Halinen and Törnroos, 2005) as the one represented by I4.0 technologies, relationships among all actors involved (Dubois and Gadde, 2002) and, in understanding dynamic interaction processes.

The case firm in focus is an innovative small-sized consulting company – Sinergia – established in 2005 by two cofounders that over the years developed its business and that currently offers a broad range of services (i.e. European Projects, Systems for Managerial Control and Risk Management, LT) mainly

addressed to local SMEs active in different sectors – furniture, mechatronics, shipbuilding, footwear – and often colocated within industrial districts in the region. Sinergia has been chosen on two grounds: it provides the perspective of a services, solutions and I4.0-related knowledge provider (Hervas-Oliver *et al.*, 2019) to the benefit of local businesses and institutions; it has developed a novel application in the I4.0 domain which is the result of an innovation path. The case analysis thus follows a processual approach (Halinen and Törnroos, 2005) based on the event and innovation path analysis (Van de Ven *et al.*, 2008; Halinen *et al.*, 2013; Purchase *et al.*, 2016) to highlight the key events related to the development of resources within the I4.0 context that occurred in the past five years. Notably, the firm has been under observation for a period of five years (2016–ongoing). The active observation has been realized from April 2019 until August 2021, while the previous years have been analyzed retrospectively.

Data has been collected through three main sources: direct semistructured interviews and participating observation conducted by one of the coauthors (Hoholm and Olsen, 2012) as primary sources, and company's websites, sectorial magazines and editorials, press briefings and corporate reports as secondary sources.

The first source of data used is one-to-one semistructured interviews (Kvale and Brinkmann, 2009). This typology of inquiry has been widely used in the IMP tradition to understand the complexity of relationships, and it has been described as “the most effective means of gathering data” (Lindgreen *et al.*, 2020, p. 2). To guide the direction of the discussed topics, similar questions were raised to all respondents, even though adapted for each specific role. Key figures – consultants in Sinergia and external partners involved in specific I4.0 projects – have been identified as informants for the interviews conducted in the timeframe April 2019–October 2021. The number of semistructured interviews is 8. Every interview had an average duration of 1 h, and all of them have been recorded and transcribed verbatim. Table 1 details the number, duration and information about interviewees.

Moreover, thanks to the involvement of one of the coauthors in the participating observation, it has always been possible to contact informants to complement information, as well as to ask for clarification on gathered data. In this sense, various

conversations and e-mail exchanges have been carried out to address specific relevant themes and updates. Participating in observation has allowed us to observe part of the process as well as it has happened (Hoholm and Olsen, 2012). Participating observations amount to 1,520 h in the timeframe April 2019–August 2021, including project coordination tools and activities (Kronlid and Baraldi, 2020) such as meetings and discussions.

Analyzing data, in line with existing studies (Halinen *et al.*, 2013; Purchase *et al.*, 2016), a timeline of the innovation path has been developed to support the identification of a series of events coded in three categories: critical, related and background. *Critical events* are used as checkpoints (Halinen *et al.*, 2013) in delineating the various phases of the survey period and are coded as such if they meet the following criterion: respondents mentioned the event as important during their narrative (Makkonen *et al.*, 2012). *Related events* are actions or activities that directly trigger or arise from the critical events but are not significant to the innovation process on their own (Purchase *et al.*, 2016). *Background events* concern the context in which the innovation is embedded, such as the macroenvironmental context and institutional forces (Purchase *et al.*, 2016).

The resulting process has been analyzed in depth using the 4R model (Håkansson and Waluszewski, 2002, 2007; Strömsten and Waluszewski, 2012). Thus, the 4R model is used as a framing mechanism (Strömsten and Waluszewski, 2012) to match the insights arising from the interviewees' knowledge and the identified critical events. In particular, resources have been classified as *products* and *facilities*, *business units* and *business relationships*, following the conceptualization of Baraldi *et al.* (2012), and their interactions have been analyzed for each critical event. This helped reconstruct the entire resource development and combination process regarding I4.0 enabling technologies whose value eventually emerges during their utilization applied to specific tasks involving other resources.

Existing studies on the model (Baraldi, 2003; Baraldi *et al.*, 2001; Baraldi and Waluszewski, 2005) have been conceptualized in the innovation and IT context. These studies have shown the interplay between IT and other resources in business networks (Baraldi, 2003) due to the embeddedness of

Table 1 Interviews' information

Company/Institution	Interviewees	No. of interviews	Duration	Period
Sinergia Consulenze	Founder and Senior Partner	3	54 min	November 2019
			1.20 h	April 2021
			25 min	December 2021
Sinergia Consulenze	Senior Consultant	4	45 min	July 2019
			1 h	February 2020
			27 min	April 2021
			40 min	October 2021
Polytechnic University of Marche	Professor of Computer Science (PUM) – Supervisor of Industrial PhD student in Artificial Intelligence	1	30 min	March 2020
University of Urbino	Industrial PhD Student (Sinergia)	1	1 h	May 2021

computerized systems, as facilities that process information “into other resources implies that their effects seldom turn out to be as expected or simply defined by their technical potentials” (Baraldi and Waluszewski, 2005, p. 1251). Considering data analysis, the recorded interviews, direct observations and the secondary data gathered have been triangulated with the aim of answering the *RQ* and examining the consistency of the different data sources. Indeed, the use of triangulation supports the qualitative research strategy of testing validity through the convergence of information from different sources (Patton, 1999). Data analysis follows the theoretical framework identified: first, we identify the main critical events of the innovation path from the interviews conducted with key informants; second, the critical events are further explored, especially by means of secondary data such as yearly technical certification on research and development (R&D) activities (produced according to Italian Law on Innovative SMEs), and, finally, each event is analyzed in-depth by looking at the different resources and classifying them first as physical and/or organizational and then by looking at their development overtime.

4. Case analysis

This section is devoted to case analysis. In the following paragraph, a brief profile of Sinergia is provided. Afterward, the evolution of the process of resource development in Sinergia will be analyzed in a processual perspective, highlighting critical events happening throughout the innovation path.

4.1 Company profile

Sinergia was established in January 2005 as a small sized management consulting company active in two main advanced service areas: European projects design and software development for managerial control, managed, respectively, by two different business units, EP and SGIA (Software for Accelerating the Integrated Management System).

The founding team was composed by two cofounders with heterogeneous background: Flavio, a Physicist and Massimiliano, a Chemist, with more than 10 years of experience in managerial consultancy and IT systems, which leveraged their expertise in 2008 developing and patenting a cloud-based software called “Integrated Enterprise Management System,” specifically designed to organize the management system in compliance with the government regulations. Thus, to better manage future developments of the software, SGIA was split into two distinct business units: the Systems for Managerial Control and Risk Management (SCI) business unit, which deals with the implementation of management systems and regulatory compliance; the LT business unit, which develops customized software solutions. In addition, in 2013, a senior consultant, currently a member of the board of directors, was hired to manage the EP business unit.

Sinergia, during the years, has gained experience in European project management, process efficiency and software development with both large and SMEs customer firms in a variety of sectors, thus positioning itself as a partner able to offer private companies and public administration support throughout the project life cycle and within the business

operations. The company has grown from four employees and a turnover of 100,000 euros to 24 employees and one million euro turnover in 2020. Sinergia is active in a region of central Italy (Marche Region), well-known for being part of the so-called “third Italy” due to its industrial structure made of microenterprises and SMEs (Potter et al., 2010), most of which are located in industrial districts. Recently the most dynamic firms – including Sinergia – have promoted the establishment of four formal clusters: Agri-food, E-living, In-Marche, Marche Manufacturing (Fondazione Cluster Marche). The region represents one of the 15 most industrialized regions in Europe and is characterized by a significant presence of the manufacturing industry, with a marked incidence of traditional sectors (Cucculelli and Lena, 2017). The company thus appears to be located in a context that can be considered “peripheral” if compared to larger and more high-tech specialized hubs and technological poles.

4.2 The innovation path in the Industry 4.0 domain

In 2016, Sinergia founders started to participate in fairs and exhibitions on I4.0 and have been invited to a trip to Germany with Benelli Armi, a local large company active in the gun sector. The trip was aimed at carrying out a study tour at the Fraunhofer Institute in Stuttgart for Benelli to understand the advantages offered by the new I4.0 paradigm and the best ways to apply it to the Benelli Armi plant (Fabbrica Futuro, 2018). After this business trip, Flavio became aware of the relevance of I4.0 for Sinergia. Given the limited size of the company and the lack of knowledge about I4.0 technologies, Flavio started to interact with other organizations – i.e. universities and companies – to explore I4.0 opportunities.

In the same years, the Italian industrial context witnessed the approval of the “National plan on Industry 4.0 2017–2020” by the Italian Ministry of Economic Development. The plan allowed for high benefits, in terms of amortization and tax credit, for firms undertaking investments on I4.0 technologies, consequently raising interest for I4.0 by industrial companies, institutions and public actors (Pagano et al., 2021).

4.2.1 Critical EVENT 1: a framework agreement with Marche polytechnic university for Industry 4.0 activities

Sinergia clearly felt that being perceived by customers as a “simple” software house was no longer sufficient to catch the market opportunities offered by these evolving technologies and the company recognized the urgency to reposition itself as an I4.0 solution provider mainly in the area of prototyping and proof of concept development. Undertaking this path is perceived as a tough challenge. On the one hand, as highlighted by the Senior EP Consultant, “many of the emerging technologies still need research, including applied research, and unfortunately, the high-tech industry is going much faster because competition is so high.” On the other hand, Sinergia is active within an industrial district in the furniture industry where “finding I4.0 applications that can be actually used [...] is not really so simple[.]” (Founder and Senior Partner).

The head of LT Department of Sinergia initially began to discuss the potential developments of I4.0 with the local Polytechnic University of Marche (PUM), already partner of the EP business unit for European R&D projects within the Smart Specialization Strategy (S3), a policy implemented in the

Marche Region since February 2014. PUM is a university located in Ancona and focused mainly on technical-scientific disciplines, such as Engineering, Economics, Medicines and Agriculture.

Since the beginning, Sinergia displayed a strong interest specifically on three of the key enabling technologies of I4.0 – augmented reality (AR) (including vision systems), advanced manufacturing solutions (robotics) and big data and analytics – as they were fully mastered by a research team named Vision Robotics and Artificial Intelligence (AI) belonging to the PUM and coordinated by a PUM professor. However, in this initial phase for Sinergia, the evaluation of technological opportunities was not an easy task. The PUM professor proposed to Sinergia a project concerning the development of AI algorithms for the recognition of the qualities of legumes. The project was financed several years later through EU funds but without the participation of Sinergia. As pointed out by the head of the LT department: “I was not yet ready to catch this opportunity, and this must be the last time [...]” This event pushed Sinergia to develop a key relationship with PUM university, which then became the main source of knowledge and insights driving Sinergia in its innovation process. Participation within the project in the context of S3 has, therefore, directly influenced Sinergia’s strategy for the development of competencies related to I4.0.

Afterward, Sinergia started participating in dissemination activities concerning I4.0 and organized by local partners. This is the case of initiatives promoted by the local business association, where the senior partners of Sinergia were invited to discuss digital technologies and opportunities brought up by I4.0.

As part of the strategy to strengthen its local network, Sinergia started to make agreements with local firms and institutions to grow and acquire the required expertise in I4.0. A framework agreement based on I4.0 themes with PUM is formalized in 2017 to enhance and boost the creation of *ad hoc* collaborations:

It’s not a contract but it’s a document that basically says you have skills that I like, and that I have skills that you like, let’s make an agreement because there are conditions to be able to collaborate when opportunities arise. (Senior EP Consultant)

Then Sinergia organized in 2018 an event on I4.0 with the collaboration of PUM Professor and of a professor of computer science at the University of Urbino (UU) to make visible to local firms and institutions the interest and commitment of Sinergia for R&D activities in I4.0.

Since 2018 Sinergia has been transformed into an *Innovative SME* (in accordance with Italian law), which has allowed it to set up formalized research contracts with universities also in the light of fiscal benefits provided by Italian legislation and develop good practices on R&D activities following the Frascati manual guidelines (OECD, 2015). In 2018, Sinergia signed a formal agreement with PUM to undertake a project entitled “Advanced Systems in Industry 4.0 Scenarios.”

This critical event contributed to the development of resources from both an organizational and technical perspective. The project resulted in the development of a Prototype of an Advanced system of I4.0 solutions for proximity visualization of technical product sheets and of facilities in the form of software, cloud and computational

technologies. Sinergia also strengthened relationships for its innovation process and created a new interorganizational business unit with PUM as a qualified supplier for the aim of the project. The new business unit is defined as a qualified supplier within an “off-site” R&D research contract (according to the Italian law). PUM was aiming to develop a localized “ecosystem” of young skilled researchers, and Sinergia aimed to create a network of firms able to host such skilled staff. In terms of technical resources, partners developed a prototype App for product localization and technical sheet visualization.

4.2.2 Critical EVENT 2: opening to universities collaborations through the setup of PhD positions

The collaboration with local universities continued and upgraded in the following years as a result of the benefits of becoming an Innovative SMEs by the Italian law and thanks to its embeddedness in the Marche manufacturing cluster.

In this sense, Sinergia has made a two-fold effort in collaborating with two local universities in both its core business units. Therefore, two PhDs have been set up thanks to scholarships provided by the European Union through the Marche Region, one related to the EP Department and the other one to the LT Department. In 2018, the Marche Region launched and financed an innovative PhD within the activities of “Marche Cluster Association” with the Department of Economics, Society and Politics of UU to develop research activities on the topic of project management and SMEs. Sinergia, being a member of Marche Manufacturing Cluster, has hosted a PhD student for two internship periods (12 months) within the EP business unit, with the goal of supporting the development of proposals for European funding on I4.0 projects. In 2019, within the framework program with PUM, an industrial PhD position has been created. The PhD scholarship is financed with European funding collected by the EP unit with the technical support of the LT unit:

The EP business units currently manages the technical-financial aspects of the project that finances a research activity within which there is the Lean Technology service that performs activities from the point of view of computer engineering. (Senior Consultant)

The main area of the PhD research project is in the Embedded Automation and Edge Computing for I4.0, which has led to the development of an AI application for AR. The key business partner in the project is Benelli Armi, which is a long-standing partner and introduced Sinergia to I4.0:

Although (Benelli) is not a company of the furniture industrial district, it is perceived as a reference point. It is clear that when you start doing scientific research of this kind, especially at the beginning, where costs are high it is clear that if you want to be the first you have to be willing to pay more and Benelli, we know, has a very high profitability and therefore can afford to do research and invest money. (Founder and senior partner)

In parallel, Sinergia continues with dissemination activities related to I4.0. Two key events have been organized: an International Winter School *BigDat2020* with PUM and other international partners, such as the Institute for Research Development, Training and Advice (IRDTA), with the goal of presenting the latest advances in the developing area of big data on a broad spectrum of academic and industrial application; the workshop “The challenge of digitization in the processes of SMEs” as part of the activities of CyberChallenge.IT 2020, a nationally relevant event for the training and selection of the National Cyberdefender Team, where Sinergia served as an

industrial partner for the PUM team coordinated by a PUM Professor. Regarding the *BigDat2020* event, the former participation of the head of the LT department to a Summer School on Deep Learning, organized by the IRDTA Committee, led to a collaboration within the 2020 event, also involving the local business association and PUM, thanks to the personal ties of Flavio. The event combined the scientific competences of PUM and the industrial ones of Sinergia, that participated as industrial chair.

In this phase, in 2019, the company collaborated on the creation of Overlux, a national network of companies with complementary expertise in digitalization processes and I4.0. The goal of this network is to satisfy – through the EP business units – the need for support of start-ups and SMEs in identifying and applying for SME-Instrument European calls for proposals on topics related to I4.0.

The two PhD projects, established in the previous phase, continued with the two PhD students developing more advanced skills and competences in their respective domains. In the words of the PhD student of UU:

Having gained experience during the first period, I felt more confident in the activities I carry out [...] I saw my contribution growing especially in the activities related to this last project, where I have been more involved also in different activities than before [...] I could work in a team composed of other PhD students. We had a supervisor, but we were allowed freedom in our activities with increasing responsibilities.

This critical event contributed to the development of resources from both an organizational and technical perspective. Sinergia, in fact, has created at the same time two new interorganizational business units, the first with UU on Project Management and the second with PUM and Benelli on AI. The features of such interorganizational units represented a novelty in terms of management of research projects. While the university usually undertakes research projects autonomously or in partnership with firms, the interorganizational business units provided a heterogeneous team. The critical event also played a role in the development of other organizational resources in the form of trustworthiness toward Sinergia. In terms of technical resources, the event resulted in the development of products as the prototype of an AI-based workbench for quality control and of facilities, for the management of the full data lifecycle, such as the red green and blue (RGB) high resolution camera, industrial lamps, pretrained neural net and object-oriented database leveraging physical computational technologies and labs.

4.2.3 Critical EVENT 3: the DeepReality project

A key turning point is represented by the XI edition of the *SMEs Day* (November 2020). The SMEs day is an event organized by the Small Industry Committee of the local business association (Marche Nord), headed by one of the founders of Sinergia since 2019, and PUM with the aim of allowing local SMEs to interact with local high schools through company tours. Within the 2020 edition, to overcome the problems related to the COVID pandemic, virtual tours of companies were created by Sinergia in collaboration with Ubisive, a local software house experienced in Unity3D programming and development of mobile App. This experience:

[...]motivated us and pushed us to turn this service into something structural. Our customer will be able to create virtual tours of their

production environments or products using immersive technologies (Web site [Sinergia Consulenze, 2020](#)).

Another related event in which the company participated in collaboration with one of the local universities is the Open Day at PUM. Sinergia together with Ubisive and PUM have attempted to develop a standard data layer as a baseline to develop serialized virtual tours. Moreover, they presented an analytic tool able to evaluate the performance of a specific virtual tour ([Pierdicca et al., 2021](#)).

The resources developed within this critical event are both organizational and technical. In terms of organizational resources, we acknowledge the emergence of business relationships and the creation of an interorganizational business unit with Ubisive and PUM dedicated to the development of virtual tours. This has enabled the development of technical resources such as the data layer that can be used for the serialization of the production of virtual tours and the AR viewer. This critical event, in the words of one of the founders of Sinergia, “allowed to integrate, get to know better and create harmony among the team in terms of competences,” leading to the later participation in the Extended Reality for all (XR4ALL) call for projects proposal.

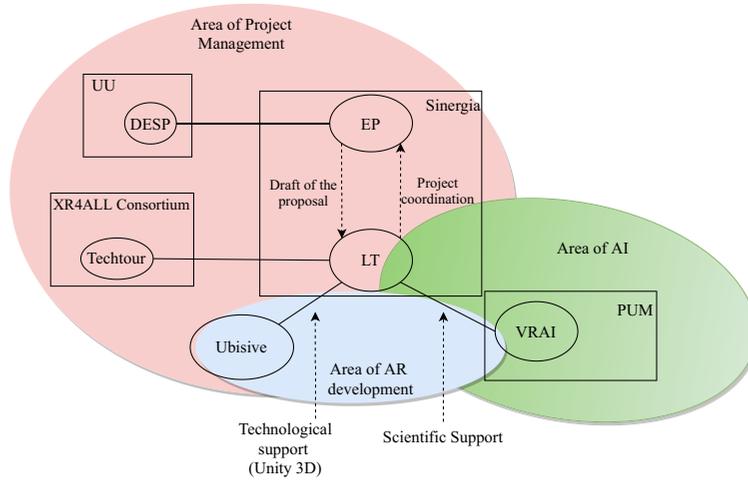
In Fall 2020, the EP business unit started scouting activities on EU call for proposals for SMEs and informed the LT department and PUM about a call for proposals in the field of AR. The call for proposal was launched as part of the activities of the XR4ALL project, an initiative funded by the European Commission through Horizon 2020 to strengthen the European Extended Reality (XR) industry (<https://xr4all.eu/about/>). The call aimed to attract, select and provide financial support in two sequential phases (phase 1, feasibility study; phase 2, development of the innovation) to third parties to develop new XR solutions [1].

Sinergia, acting as a project coordinator, PUM and Ubisive developed the project proposal named “DeepReality, automatic Content Generation for eXtended Reality Applications,” later submitted at the end of 2020 to the XR4ALL consortium. DeepReality project, by implementing a Unity Plug-in, specifically designed to enable an integration of Deep Learning algorithms within AR applications, was aimed at addressing two complex issues related to AR applications development, namely, robustness of environmental tracking and generalizability of content creation.

Sinergia won the grant with both the scientific and technical support of PUM and Ubisive, leveraging both the EP expertise in Project Management of EU projects for SMEs and LT know-how in IT and then developed the innovation embedded within the DeepReality Project. The project started officially started at the beginning of February 2021 and in August 2021, Sinergia released under MIT License version 1.0 of a Software development kit (SDK) for Unity3D environment aimed at simplifying and optimizing the use of Deep learning models in the development process of AR applications mainly for industrial, while still implementing a Software as a Service for paid licenses based on cloud. [Figure 2](#) depicts the network of the project.

Winning the competition for the European project allowed Sinergia to rethink its positioning within the regional business landscape as a technological partner – and not only as a broker or mediator – in I4.0 projects. Before “in the 4.0 part, thus far

Figure 2 Sinergia’s network and competence areas around the European Project XR4ALL



our historical customers did not perceive us as potential partners because we haven’t even proposed to them with all the 4.0 activities.” (Founder and Senior partner). After winning this project, initial contacts have been launched with leading local industrial firms in traditional sectors for possible technological consultancies in the I4.0 domain.

In the words of one of Sinergia founders, the company has been able to “achieve the creation of an ecosystem of collaboration with universities” that has fostered, at the beginning, the integration of internal and external competences of the company creating stable links with business/nonbusiness actors, in a logic of open innovation. The open innovation approach adopted by the company has also been recognized as a best practice in the business community (Website Osservatorio Open Innovation e Corporate Venture Capital, 2021 <https://osservatorio-openinnovation.it/>).

Becoming a I4.0 technology provider has been a difficult and complex process for Sinergia. A key role has been played by the strategic partnership with PUM. In the words of the Sinergia founder: “[...]there is a special empathy and feeling with PUM Professor. Without that, I would not have been able to accomplish this.” Sinergia perceives the Polytechnic of Milan – recently partnering with local industrial firms – as a main competitor due to its “large structure, also with an ecosystem of

company spin-offs” (Founder and Senior Partner). Therefore, Sinergia has recently reorganized its corporate governance and is planning to setup an *ad hoc* start-up jointly with PUM (website Osservatorio Open Innovation e Corporate Venture Capital, 2021 <https://osservatorio-openinnovation.it/>) to effectively manage current and future projects related to I4.0.

The critical event DeepReality project represents the synthesis of both organizational and technical resources previously developed and assembled by Sinergia (Figure 3 depicts Sinergia’s innovation path). In fact, leveraging on business units and relationships previously created, Sinergia has developed technical resources such as the SDK for AR applications and programming languages, equipment, computational technologies and clouds.

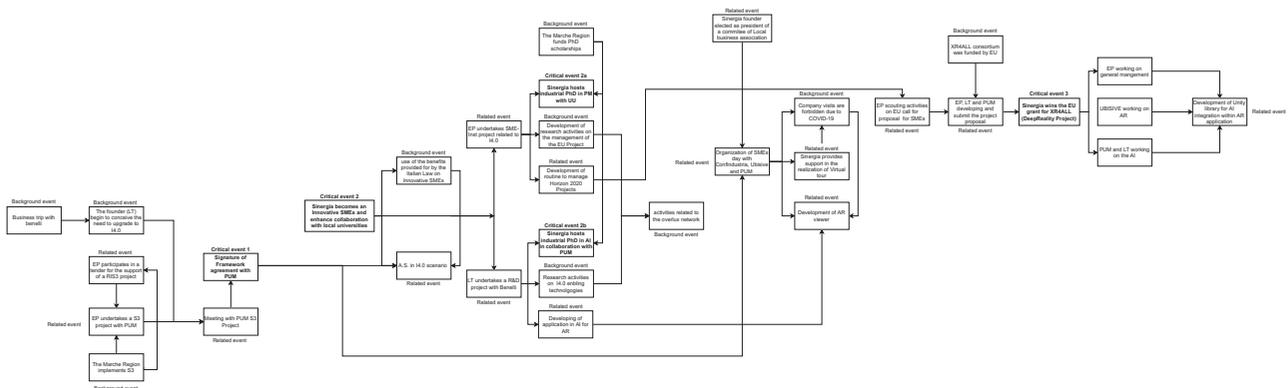
5. Discussion

The case analysis provides useful evidence and insights to address the RQ and allows discussing resource development processes in the innovation path of a small consulting firm in the I4.0 setting.

5.1 The innovation path

Drawing on Purchase et al. (2016), the coding of critical events highlights the embedded and temporal nature of the innovation

Figure 3 Events-based innovation path



path undertaken by Sinergia – in connection with the development of the network around them (Hedaa and Törnroos, 2008).

The establishment of a framework agreement (Mouzas and Ford, 2012) and business relationships with selected actors in the local academic and business setting – already familiar and active in the I4.0 trajectory – represent key activities allowing to tap into valuable technological and managerial resources. In terms of technical resources, the first critical event led to the development of new products, such as the prototype of an advanced system of I4.0 solutions for the proximity visualization of product datasheets, and facilities in the form of software, cloud and computational technologies. While in terms of organizational resources, it has fostered the establishment of an off-site business unit dedicated to R&D activities, showing the emergence of “resource-oriented networking” with key local players in the I4.0 setting.

The new status of innovative SMEs and enhanced collaboration with local universities, which emerge in the second critical event, led to the establishment of new partnerships with local universities, PUM and UU, through the launch and implementation of industrial PhD projects. Two main patterns emerge in this phase. First, the PhD students involved in the joint industrial projects started to play a main role in terms of technological and managerial competences thanks to the learning process implemented in their universities and in the companies where they have been involved (Fremont et al., 2019; Ciarmatori et al., 2018). The newly developed industrial PhD positions represent channels for stronger interaction and knowledge exchange between academia and business (Rubach et al., 2017). Second, within Sinergia, there has been an effort in integrating technological expertise and project management skills developed in two internal Business Units (LT and EP) to better address I4.0 projects. Therefore, the second phase is characterized by “hybrid resource development,” as the joint technical resources development is shaped by the emergence and consolidation of interorganizational resources represented by the PhD positions.

Finally, the successful participation in a highly competitive European call for proposal on I4.0-related technologies, which has led to the implementation of the DeepReality project, showed as Sinergia has been active in exploiting unexpected opportunities – as the start of a collaboration with the software company Ubisive, to integrate valuable technological expertise. Success in the DeepReality project has been based on the further integration at the intraorganizational level within Sinergia and at the interorganizational one with both the scientific (PUM) and technological (Ubisive) partners. Stronger cooperation has been crucial to autonomously monitor, identify and eventually respond to the European calls for proposals which represent one of the main sources of funding for innovation projects undertaken by SMEs; and to develop a set of tools for software development. In relation to the DeepReality Project, a new tailored organizational unit has been established for the project lifetime (February 2021–August 2021) in the form of Project Management Office (PMO) of the consortium, involving the company, the University and Ubisive. This third phase is thus characterized by “resource assembly” within both intra- and inter-

organizational settings, building on the resource structure developed across the two previous critical events.

Therefore, Sinergia’s innovation path is characterized by three patterns in terms of resource development:

- 1 resource-oriented networking;
- 2 hybrid resource development; and
- 3 resource assembly.

Resource-oriented networking was initiated by Sinergia to connect with the technological frontier in I4.0, and it is characterized by the development of *ad hoc* organizational resources and by the internal technical expertise of the company. Hybrid resource development allowed for setting up a joint resource structure with key partners, based on a system of relationships with actors from business and academia to explore and exploit the opportunities of I4.0 (Sjöo and Hellström, 2021) by leveraging managerial skills and pooling the know-how of all partners. Finally, resource assembly resulted in achieving the ability of effectively combining internal and external resources in new configurations with a strategizing view (Lind et al., 2012; Ciabuschi et al., 2012). Sinergia has pursued an innovation path where the development of organizational resources represented the setting where scientific and technological resources could be accessed, developed and then assembled in key projects. Table 2 provides details over the resources developed along the identified critical events.

It can be argued that the result of this path is the shift in the role played by Sinergia from *knowledge broker* to *solution provider* in the highly competitive I4.0 setting. This process is characterized by a strong networked nature, as shown by the building up of a “local inner network coalition” composed by Sinergia and its local business and nonbusiness partners – ecosystem of collaborations’, in the words of Sinergia. Sinergia has implemented a localized open innovation approach involving key partners recognized for their expertise in the I4.0 context.

Becoming a solution provider has meant – in the perception of Sinergia – a rethinking of its positioning within its business landscape as a technological partner, pursuing a distinct “identity” in the I4.0 context at the local/regional level (Hervas-Oliver et al., 2019; Baraldi et al., 2020; Huemer, 2013). The identity building process has been shaped overtime by the strategic alignment of the company with its key partner – the PUM research group on robotic vision and AI – in the innovation path.

It should be highlighted that this key business relationship has been shaped by the strengthening of personal ties (Granovetter, 1973; Halinen and Salmi, 2001) between the head of the LT department and the PUM Professor. The existence of personal trust and esteem – leading to stronger reputation (Musiolik et al., 2012) – has been itself a key resource (Baraldi et al., 2012), which allowed for the mobilization of valuable technological and organizational resources. The focus on organizational resources has been meant to provide an organizational architecture to monitor emerging technological solutions and adapt the innovation path pursued by the company.

Table 2 Resource development along the identified stage

Critical event	Products	Technical resources		Organizational resources	
		Facilities	Business units	Business relationships	
1	Prototype of an advanced system of I4.0 solutions for proximity visualization of technical product datasheet	Software for mobile application development (Xamarin - AltBeacon) Microsoft Azure cloud (Microsoft AppCenter) Computational physical technologies (Beacon BLE)	Sinergia: LT department PUM LT and PUM: off-site BU devoted to R&D activities	PUM	
2	Prototype of an AI-based workbench for quality control	RGB high resolution camera Industrial lamps Pretrained neural net Object-oriented Database Computational technologies Labs	Sinergia: LT department Benelli: QC PUM: PhD position in AI UU: PhD in PM Local business association PUM UU	Benelli PUM Ubisive Local Business Association Overlux UU	
3	AR Viewer for Virtual tour (Application for smartphone and physical product) Software development kit	Software for mobile application development Physical viewer Unity3D environment, Python programming language Google Colab, Microsoft Azure Android and iOS smartphones Computational technologies	Sinergia: LT, EP departments Ubisive PUM: PUM PhD position in AI UU: PhD position in PM PMO of the XR4ALL consortium	Ubisive PUM UU XR4ALL consortium	

5.2 Resource interaction

The use of the 4Rs shows how the innovation path followed by Sinergia has led to a process of resource assembly (Håkansson and Waluszewski, 2002; Arthur and Polak, 2006).

The empirical analysis highlights how continuous interaction – combined at the early stage of the process with the exploitation of the fiscal incentives provided by Italian legislation – fostered the development of technical resources in terms of prototypes of I4.0 solutions (i.e. creation of a structured service on digitalization and I4.0), of facilities (software, tools for software development and computational technologies held by Sinergia and University partners) and organizational resources such as PhD positions, European project management expertise, company and individual reputation and key business relationships (with PUM, UU and selected business partners and local institutions). This allowed the focal company to reach both a business readiness level and a technology readiness level such that it can deal with the new challenges raised by I4.0. Eventually, the innovation path pursued by Sinergia is characterized by a incremental upgrading and integration of technical and organizational resources in the network (Gadde and Håkansson, 2008).

I4.0 represents, in this respect, a stimulating and novel context with regard to resource development and interaction to test the 4 R model. Differently from “traditional” IT systems – defined as artifacts used to create or transform products and information (Baraldi, 2003; Baraldi and Waluszewski, 2005) – within the I4.0 domain and in the wider context of advanced digital technologies actors have to manage physical aspects and computational and organizational processes in a completely

new integrated way (Lee, 2008). Case analysis showed how computational procedures – constituting the so-called “behind the curtain” elements (Baraldi, 2003, p. 3) – developed by Sinergia in an early stage of its path have been reused with different forms in different applications thanks to their characteristics of reusability and reprogrammability. From the Sinergia perspective, computational procedures represented products developed by organizational units using facilities – such as physical computer technology and software – to create or reconfigure a facility in the house of the user, who, in turn, affected both the physical and organizational resources of the provider by making use of it. If we consider products and facilities in the I4.0 context as “cyber resources” (Ross et al., 2021), these resources are not purely physical items nor have very clear physical properties (Håkansson and Waluszewski, 2002): computational procedures represent the procedures or routines inscribed in IT systems that allow them to “mimic” the behavior of a business unit (Baraldi and Waluszewski, 2005) with higher standard of reliability and predictability; concurrently, they require low investments in the light of their open-source nature, being, therefore, more suitable for SMEs.

The case shows how, within the current general digital setting and in the I4.0 in particular, the link between physical resources – products and facilities – and intangible resources is as close and interdependent as ever in the light of the concepts such as Cyber Physical Systems (Lee, 2015; Xu and Duan, 2019) and Internet of Things (Falkenreck and Wagner, 2018) that refer to systems that combine physical dynamics with computational procedures, also described as an orchestration of computers and physical systems which enable to deploy and

deliver applications very fast and scale across a distributed environment thanks to their layered modular architecture (Yoo, 2010) built for bridging the digital and physical world (Pardo et al., 2020).

Sinergia effectively coped with the evolving nature of the resources involved in the I4.0 domain, contributing to the resource interaction process through an increasing resource assembly effort which allowed to fastly design and deliver solutions through the exploitation of emerging computational procedures (Yoo, 2010). This upgrading process – as outlined above – has been possible in the light of the development of a network of business relationships providing a stable organizational setting for the innovative effort related to I4.0 complex solutions. In this sense, this case study is able to provide interesting insights over the required challenging steps and processes to be implemented by small consulting firms facing I4.0 contexts in their relationships with small and medium customers.

6. Conclusions

This study explores the resource development process implemented by a small consulting firm, active in a traditional industrial context, in its I4.0-related innovation path. Through critical event analysis (Purchase et al., 2016) and the adoption of the 4Rs model (Baraldi et al., 2012), the case study analysis highlights the main features of a transition from knowledge broker to solution provider. Notably, this research shows the emergence of three main patterns in the evolution of the innovation path: resource-oriented networking, hybrid resource development and resource assembly. Within this process, having a strong networked nature and showing a clear “strategizing effort,” the development of key organizational resources – business relationships with local leading actors, hybrid organizational units, and a corporate identity increasingly related to I4.0 – provide the context for the development and combination through the interaction of technological knowledge and resources with the contribution of key scientific and technological partners. Therefore, this research provides a contribution to the growing literature on adoption and diffusion of I4.0 solutions (Frank et al., 2019; Hervas-Oliver et al., 2019), analyzing the overlooked perspective of the small consulting firms (Vuksanović Herceg et al., 2020) in its transition from knowledge broker to solution provider active in SMEs’ digital transformation process. Undertaking I4.0 projects could be a challenging task for those firms and organizations supposed to help and support industrial firms and, notably SMEs.

The case analysis also contributes to IMP literature in the context of Resource Interaction both from a methodological perspective and from a theoretical standpoint.

For what concerns the methodological contribution, adopting a processual perspective (Halinen and Törnroos, 2005) over the resource development process within the innovation path by means of events (Purchase et al., 2016) has represented a useful research tool to capture processes and dynamics in the context of business networks evolution. Notably, the critical event analysis allows to effectively develop the resource interaction model by highlighting how technical

and organizational resources have been developed and assembled in the key identified events.

Under the theoretical perspective, the paper sheds light over two interrelated issues as called by Bocconcelli et al. (2020). First, the study adopts the 4R model in a highly complex technological context characterized by fast-paced changes. Building on existing IMP studies dealing with resources in the IT context (Baraldi, 2003; Baraldi and Waluszewski, 2005), this research contributes by showing how the increasing technological complexity of these systems brought about by I4.0, and characterized by a collaborative and open-source nature, requires a much stronger interaction between technical and organizational resources. In particular, while the category of organizational resources has been further conceptualized – encompassing a wide range of elements such as trust, reputation and identity – the study highlights the need for a further investigation of the category of technical resources in the light of the I4.0 context in which they display new and evolving features. The case sheds a first light on the blurred boundaries between physical and organizational resources, generating a resource interaction process characterized by a greater interdependence. Technical resources are difficult to be categorized exclusively as products or artifacts, as they can be considered as products developed by organizational units, using facilities to create or reconfigure a facility through its deployment made by the users, thus changing the way value is generated within interactive business relationships.

Second, the new emerging resource structure in the I4.0 domain, characterized by a process of networking and assembly of internal, external and shared resources following an open innovation logic, leads to changing roles of actors within the network in which they operate (Hedaa and Törnroos, 2008). The changing role of actors in the network is closely related to emerging technical resources related to I4.0, as shown by the new positioning of Sinergia as a provider of I4.0 solutions within the local context.

The empirical research undertaken in this paper has various managerial implications for small consulting firms active in the I4.0 setting. The first one concerns the key role of “business networking” activities (Rusanen et al., 2014) to effectively navigate into multiple networks, shaped by different logics – business, University and European institutions – and embedded in a regional context which is not “core” in the IT and I4.0 context. For a small consulting firm pursuing a I4.0 positioning in the market represents a great challenge requiring managerial vision and capabilities. Second, this effort requires setting up an appropriate organizational configuration for developing I4.0 projects to maintain overtime control and access to key technological expertise in a context where there is a strong competition for this type of resources by both large industrial and service firms and by leading Universities and Research centers. Third, participation in small-scale I4.0 projects funded by the European community with the objective of producing open-source software could represent one of the most suitable model for smaller consulting firms to verify both the commercial viability of a product and the possible support of the community of developers while ensuring a stronger control over intellectual property rights of the innovation proposed.

This research also entails relevant policy implications. The diffusion of I4.0 technologies is shaped by the involvement of industrial firms – often operating in traditional and medium-technology sectors – in dynamic innovation networks where a variety of knowledge brokers and providers are active. Local small/medium consulting firms in the past decade have been increasingly partnering with industrial firms in their technological and organizational upgrading processes. It could be useful to devise appropriate policy mechanisms to make this cooperation more stable and oriented toward innovative technologies as those related to I4.0, with the involvement of universities and research centers. As the Sinergia case shows, joint Industrial PhD projects could represent key mechanisms to transfer and combine knowledge in these industrial settings.

Moreover, this study emphasizes that the I4.0 setting is much more than what is assumed from a policymaking perspective. The general policy interpretation of this phenomenon is strictly connected to its tangible dimension, seeing I4.0 as a process of technology transfer and adoption. Recently, there has been a shift toward the intangible features of I4.0 implementation in terms of enhanced collaboration among “triple helix actors” (Reischauer, 2018). We argue that a resource interaction view could provide a useful perspective of the business and institutional context where I4.0 projects – often having an interorganizational dimension – and their localized learning processes are implemented.

This study does not come without limitations. The research accounts for the perspective of the small solution provider in the I4.0 context and for its network of partners in the innovation process. Thus, while the focus is on the producing and developing settings, the main limitation of the study is that it does not investigate in depth the using setting. A future interesting research avenue could be adopting a full DPU lens, focusing on the three embedding settings of “developing,” “producing” and “using” (Håkansson and Waluszewski, 2007; Ingemansson and Waluszewski, 2009).

Note

- 1 “XR” – is the umbrella term used for virtual reality, augmented reality (AR) and mixed reality.

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