The different shades of innovation emergence in smart service systems: the case of Italian cluster for aerospace technology

Orlando Troisi
University of Salerno, Fisciano, Italy
Anna Visvizi
SGH Warsaw School of Economics, Warsaw, Poland, and
Mara Grimaldi
Department of Business Science, Management and Innovation Systems, University of Salerno, Fisciano, Italy

Abstract

Purpose – The purpose of this paper is to explore the emergence of innovation in smart service systems to conceptualize how actor's relationships through technology-enabled interactions can give birth to novel technologies, processes, strategies and value. The objectives of the study are: to detect the different enablers that activate innovation in smart service systems; and to explore how these can lead dynamically to the emergence of different innovation patterns.

Design/methodology/approach – The empirical research adopts an approach based on constructivist grounded theory, performed through observation and semi-structured interviews to investigate the development of innovation in the Italian CTNA (Italian acronym of National Cluster for Aerospace Technology).

Findings – The identification and re-elaboration of the novelties that emerged from the analysis of the Cluster allow the elaboration of a diagram that classifies five different shades of innovation, introduced through some related theoretical propositions: technological; process; business model and data-driven; social and eco-sustainable; and practice-based.

Originality/value – The paper embraces a synthesis view that detects the enabling structural and systems dimensions for innovation (the "what") and the way in which these can be combined to create new technologies, resources, values and social rules (the "how" dimension). The classification of five different kinds of innovation can contribute to enrich extant research on value co-creation and innovation and can shed light on how given technologies and relational strategies can produce varied innovation outcomes according to the diverse stakeholders engaged.

Keywords Innovation, Value co-creation, Technology, Cluster, Service innovation, Smart service systems, Service science

Paper type Research paper

1. Introduction

In line with the advent of markets digitization, contemporary organizations are reconceptualized as *smart service systems* (Lim *et al.*, 2016; Lim and Maglio, 2019), characterized by increased connectivity that boosts information sharing and offers the opportunity to collect and compute data by enhancing innovation opportunities (Medina-Borja, 2015; Spohrer and Demirkan, 2015).

Despite the recognized impact of technology on the development of innovation, extant research broadens the focus from the study of "mere" technological innovation (new or improved products/services, processes, OECD, 2005) to the adoption of a systems orientation (Vargo *et al.*, 2015) that identifies the need to integrate the technological dimension with the human and social side of innovation.

Thus, technology *per se* does not allow the automatic attainment of innovation: it is only through the right application of flexible skills and knowledge that innovation can be realized successfully.

The exploration of the enablers for technological change can be addressed through the lenses of service science. In particular, the concept of smart service systems (Barile and Polese, 2010) seems to be suitable for an in-depth investigation of how innovation can be pursued systematically through the use of new technologies and enhanced information flows that, by means of learning-based mechanisms (Lim and Maglio, 2019), can give birth to new knowledge and social transformations.

However, even if systems view allows at widening the scope of research on technological innovation, studies on service

The current issue and full text archive of this journal is available on Emerald Insight at: **https://www.emerald.com/insight/0885-8624.htm**

Journal of Business & Industrial Marketing
Emerald Publishing Limited [ISSN 0885-8624]
[DOI 10.1108/JBIM-02-2020-0091]

Received 10 February 2020
Revised 6 October 2020
Accepted 13 December 2020

science stress the necessity for the examination of the transformative role of information and communication technologies (ICTs) (Akaka *et al.*, 2019) to understand how new value can be co-created in complex business-to-business (B2B) service systems (Breidbach and Maglio, 2016).

Moreover, in line with Gummesson and Polese (2009) and Polese (2009), Polese *et al.* (2018), value and service exchanges in B2B should be not considered as different from business-to-consumer (B2C) relationships, as the real object of study is not the power dominance in suppliers–consumers relationship but the practices, the roles and the resources integrated among "generic" value co-creating actors (Vargo and Lusch, 2011).

Hence, the aim of the study is to combine systems and transformative view on innovation to reveal, firstly, the key enabling dimensions of innovation, and to explore, secondly, how these can be combined dynamically across multiple actor's relationships, knowledge integration processes and practices exchanges to give birth to new technologies, processes, strategies and value. The different "novelties" co-developed (new services, resources, knowledge, value, social elements, rules) can foster innovation systemically and cyclically to renew the value co-created over time towards the attainment of sustained innovation. Thus, the main goals of the study are:

- to detect the different dimensions [across multiple patterns of relationships, activities and contexts of exchange, B2B, B2C, C2C ... actor-for-actor (A4A)] that activate innovation mechanisms in smart service systems;
- to explore how these enabling dimensions can lead dynamically to the emergence of different innovation patterns.

The empirical research is performed through constructivist grounded theory (Mills *et al.*, 2006; Gummesson, 2017), based on observation and semi-structured interviews to analyze the development of innovation in the Italian CTNA (Italian acronym of *National Cluster for Aerospace Technology*).

The findings reveal the systems and systematic features of continuous innovation in smart service systems and allow the introduction of a diagram that classifies the different types of innovation emerged in the cluster, conceptualized through some related theoretical propositions.

The paper is structured as follows. In the first section, a theoretical background on the main enabling dimensions for value co-creation and innovation in smart service systems is presented. Then, the methodological procedure used to perform the empirical research through a mixed qualitative approach is described. The findings are debated and a diagram that describes five shades of innovation in smart service systems is introduced. Finally, conclusion, implications and limitations of the work are discussed.

2. Theoretical background

The most recent theories on service redefine organizations as complex service systems that, through the interactions between actors, enhanced by smart technologies and ICTs, can co-create value (Davis *et al.*, 2011). The introduction of the concept of smart service systems (Barile and Polese, 2010; Lim and Maglio, 2019) in service science [also known as *service science, management, engineering and design SSMED*, Spohrer *et al.* (2007), Maglio and Spohrer, 2008) allows the exploration of the impact of information flows on value co-creation to identify the enablers for systematic innovation.

For this reason, the current section defines the concept of smart service systems (Section 2.1) and explores the different approaches to innovation (Section 2.2) introduced in extant research.

2.1 From service systems to smart service systems: the key enablers of value co-creation

Service science (Spohrer *et al.*, 2007) aims at conceptualizing the mechanisms that generate value co-creation across humans' interactions mediated through technologies and oriented towards common goals. The theory defines organizations as service systems that are "value co-creation configurations of people, technologies, value propositions, that interact with other service systems internally and externally through shared information" (Spohrer *et al.*, 2008, p. 5).

In line with the advent of markets digitization, service systems are reframed as smart service systems (Barile and Polese, 2010; Lim *et al.*, 2016) in which ICT tools can provide organizations with new ways to increase co-creation and, thus, innovation (Edvardsson *et al.*, 2015).

The main dimensions of service systems (people, organizations, technology, shared information) can be redefined actively by smart technologies which enhance automation and connectivity and empower interactions and information exchanges between people and organizations (Lim *et al.*, 2016). Smart organizations embedded in each other's co-create value by means of the synergy arising from some critical dimensions, the so-called 4Cs (Lim and Maglio, 2019): connection; collection of data; communication; and computation.

As Figure 1 shows, the smart reinterpretation of service systems can be conceptualized through the following assumptions:

- the interactions *organizations-people* (*connection*) are strengthened and intensified through the proliferation of the points of contact or technological channels (*things*);
- the *information* exchanged is *shared* in an immediate and transparent way (*communication*);
- *technologies* enable the continuous collection of data (*data collection*);
- data are analyzed through the application of analytics (*computation*) to extract information and new value.

The dynamic and unrepeatable combination of the dimensions depicted in Figure 1 can give birth to value co-creation and to the systematic creation of innovation (Carrubbo *et al.*, 2015) by spreading in the system a constant innovative tension to re-configuration and proactive co-evolution. Therefore, detecting the resources integration among people mediated by technology to derive value co-creation (Badinelli and Sarno, 2016) permits to identify the enablers of the emergence of innovation.

However, in B2B research, there is the need to reveal how complex service systems (Breidbach and Maglio, 2016) are enhanced through the transformative role of ICTs (Akaka *et al.*, 2019) to detect which are the main drivers that, combined dynamically, can release innovation (Frost and Lyons, 2017) and how they affect the relationships actors-technology and the interactions human-machine. In addition, any differences between B2B and B2C relationships and interactions should be removed (Alexander and Jaakkola, 2011) to explore the overarching role performed by "co-creators" (Vargo and Lusch, 2016; Polese *et al.*, 2018), rather than users or providers. It is not possible to distinguish the single contributions of users or providers, as value co-creation is a process and the novel elements that support innovation are entities emerging from a totalizing value exchange.

Hence, to address these gaps and embrace service systems view, the work seeks to address the following research question:

RQ1. Which are the main enabling dimensions (across multiple patterns of relationships and contexts of exchange, B2B, B2C, C2C...A4A) that activate innovation mechanisms in smart service systems?

2.2 Innovation emergence in service: towards a systems and systematic view

Innovation is defined traditionally as the result of new or significant improvements in products, services or organizational and market practices (OECD, 2005). Thus, the innovative outcomes can involve different areas and business departments, from the development of products (R&D) to operations and production, to employees' management and marketing.

Over time, the capacity of innovation – and subsequently its definition – has grown to encompass the human and cultural dimensions (Ugolini, 2004) that, together with technology, can raise the possibilities to innovate.

Simultaneously, the studies on service innovation shift gradually the attention from the analysis of "mere" technological innovation, thus the development of new or improved products/services, processes, organizational methods (Snyder *et al.*, 2016), to the adoption of a systems orientation (Vargo *et al.*, 2015).

Despite the recognized impact of technology (Ugolini, 1999), there is the need to shed light on the human and social side of innovation. Technological tools do not automatically imply the achievement of innovation: it the way in which people activate them through knowledge exchange (Baccarani, 2011; Maglio *et al.*, 2006) can foster the emergence of innovative entities.

The widening of the conceptualization of innovation introduced in service science is in line with the gradual proposition of a systems perspective on service innovation (Lusch and Nambisan, 2015). As synthesized in Table 1, in extant research on service there is the coexistence of four different views (not considered as opposite but as complementary), focusing on diverse enablers of innovation: *technology-driven approach*; *knowledge-based approach*; *social-oriented approach*; *human-centred approach*.

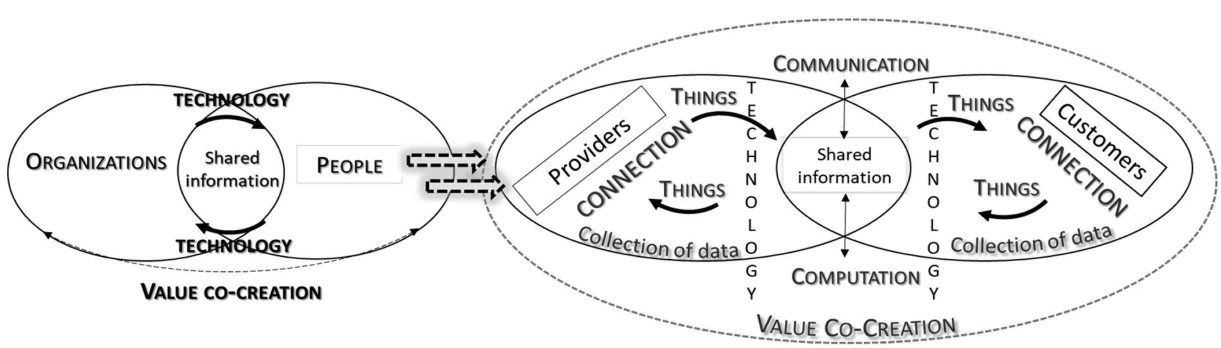
In *technology-driven approach*, technologies are considered as the main levers to enable co-creation and then, innovation (Löbler and Lusch, 2014). Technological platforms are defined from a structural point of view through some criteria as transparency, accessibility, adaptability to internal changes (Nenonen *et al.*, 2012; Ramaswamy and Gouillart, 2010) and are intended as necessary drivers for innovation (Neuhofer *et al.*, 2012; Breidbach and Brodie, 2017).

Knowledge-based approach considers the sharing of actors' knowledge as the essential driver to use technology efficiently and to improve services or create new ones. Thus, the need to perceive actors as "knowledge workers" (Maglio *et al.*, 2006, p. 83) is conceptualized to reread innovation as a "collective that links knowledgeable actors" (Mele and Russo-Spena, 2019, p. 125). Innovation can be defined as the result of the creation of new knowledge to solve a problem, created intentionally or unintentionally (Gallouj, 2002; Dougherty, 2004). Technology is still a central element but is not viewed as the unique enabler, rather as a (physical) tool that empowers knowledge application and as a context-dependent variable that should be negotiated necessarily through human interactions and resource integration (Martín-de Castro *et al.*, 2011).

According to *social-oriented approach*, the social sphere influences value co-creation and creates innovation. Rules, beliefs, power relations and institutions can form value co-creation (Peredo and Chrisman, 2006; Lusch and Nambisan, 2015; Vargo *et al.*, 2015) and encourage the use of technology by increasing business growth, competitive advantages and innovation. The relationships with stakeholders can be the sources of organizational change (Yu and Sangiorgi, 2018; Jonas *et al.*, 2016) and can give birth to new social elements, practices (Orlikowski *et al.*, 2000) or rules (institutions in S-D logic, Koskela-Huotari *et al.*, 2016) but also to new meanings and symbols (Siltaloppi *et al.*, 2016).

Finally, *human-centred approach* posits that technologies should be integrated with a right combination of human-machine interactions (Mele and Russo-Spena, 2019). The

Figure 1 Conceptualizing the transition from service systems to smart service systems



Source: Authors' elaboration

Table 1 Different approaches to innovation in service research

Authors	Approach	Enabler of innovation
Ramaswamy and Gouillart (2010) Nenonen *et al.* (2012) Breidbach and Brodie (2017)	Technology-driven	Technology adoption and use of tools and platforms that boost value exchanges
Gallouj (2002) Dougherty (2004) Maglio *et al.* (2006) Martín-de Castro *et al.* (2011)	Knowledge-based	Process of resource integration that turns actors into knowledge workers
Peredo and Chrisman (2006) Lusch and Nambisan (2015) Vargo *et al.* (2015) Siltaloppi *et al.* (2016) Koskela-Huotari *et al.* (2016)	Social-oriented	Context-based institutions and rules that shape social connections and roles
Blomkvist *et al.* (2011) Mele and Russo-Spena (2019) Sangiorgi *et al.* (2019) Piciocchi *et al.* (2019)	Human-centred	Human's behaviours, attitude, capabilities to extract value and novel elements from the information and knowledge shared

Source: Our elaboration

unique actors' integration of resources and capabilities boosted from technologies (Piciocchi *et al*, 2019), can enable the development of innovation. According to this perspective, innovation arises from a creative and iterative approach based on actors' collaboration (Sangiorgi *et al.*, 2019; Blomkvist *et al.*, 2011). The focus is on individuals' behaviours, emotions and abilities to extract insights and value from information (Maglio *et al.*, 2015; Breidbach and Maglio, 2016), rather than on the knowledge exchanged.

Therefore, it can be noticed that the last advancements in research on service innovation and service systems (Piciocchi *et al.*, 2019) introduce a systems and transcending view (Vargo *et al.*, 2015) that integrates the different dimensions identified in Table 1. According to this perspective, service innovation is reframed as the re-bundling of a heterogeneous set of resources, actors and contexts underlying service exchange (Lusch and Nambisan, 2015; Barrett *et al.*, 2015).

Despite the proposition of a systems approach to innovation, there is still the need for further research that analyses how the enabling dimensions of innovation, above all the disruptive power of technology, could make changes in the "old" B2C and B2B practices (Wiersema, 2013).

It follows that the exploration of innovation emergence in smart service systems cannot be grounded not only on the identification of the main enablers of new co-created value (*RQ1*) but also on "how" these elements can be integrated (and managed) dynamically through constant process of adaptation and reconfiguration. Therefore, a second research question can be introduced:

RQ2. How can the enabling dimensions of innovation lead dynamically to the emergence of different innovation patterns?

3. Methodology

The empirical research is performed through constructivist grounded theory (Strauss and Corbin, 1994; Charmaz, 2000) based on abduction (Glaser, 2002; Dubois and Gadde, 2014). A multi-method approach is adopted that integrates observations, focus groups and semi-structured interviews, administered to a set of key stakeholders that operate and co-operate across Italian CTNA (Italian acronym of *National Cluster for Aerospace Technology*).

The qualitative approach, based on a multi-method research design (described in Section 3.1) and on a multi-stage research procedure (described in Section 3.2), is considered suitable to meet the multidimensional goals of the study (see *RQs*), which aim at assessing different variables at multiple levels of analysis across varied systems embedded in each other with diverse relational modalities.

3.1 Research design

To take into account the exploratory nature of the research questions ("which" and "how" rather than "why" questions that aim at validating causal effects), the work adopts a qualitative approach based on the realization of a case study conducted through constructivist grounded theory (Mills *et al.*, 2006).

The case study methodology is selected to explore deeply the phenomenon of innovation emergence in multiple contexts and to disclose the activities, resources, skills that surround the process.

The case selected is Italian Cluster for Aerospace Technology, reread as a smart service system. Clusters are sets of embedded firms that settle strategic collaborations to pursue the general technological development (Karlsson *et al.*, 2005) of the segment and to increase innovation opportunities and competitiveness for the entire industry. Thus, they are suitable for an analysis of the impact of technology on innovation and on the growth of a networked service system beyond limited geographical boundaries.

Due to the networked layout of clusters, embedded case study (Yin, 2011) is adopted. The unit of analysis (the entire system of Technology Cluster) is divided into sub-units, which are embedded service systems that engage with the others through interaction modalities, activities and technologies tools by creating multi-levelled resources exchanges.

Grounded theory (Glaser and Strauss, 1967; Strauss and Corbin, 1994) consists of iterative rounds of observation (data) and of induction (theory) that connect the insights gained from literature to develop conceptual categories useful for the proposition of an innovative theory (Strauss and Corbin, 1998). In this study, this method is used according to a constructivist approach (Dubois and Gadde, 2014; Gummesson, 2017), grounded on cycles of interpretation and co-creation of meanings between researchers and participants. The abductive elaboration of new theoretical concepts (*theory-building*, Eisenhardt, 1989) mediates continually between observation (data), induction (reconnecting data to theory) and deduction (reinterpreting extant theory to propose new concepts).

A multi-method approach is used (Brewer and Hunter, 2006) based on the integration of different techniques to enrich generalizability of the findings. By varying the nature and the sources of the data collected, the research involves a design based on semi-structured interviews, observations and focus groups conducted over a time span of one year.

The final sample, described in Table 2, is composed of 31 interviewees, belonging to 17 different companies-institutions, selected from the main sub-systems identified in the Cluster (the first column in the Table). To preserve the identity of the companies, names are not revealed in the paper, but the organizations investigated are renamed with their role in the network.

Focus groups have been held at the end of each round to corroborate the data collected in the previous steps with interviewees' opinions, to assess researcher's interpretation and to create new issues. Four meetings have been performed, one for each phase to verify the validity of the issues emerged in the various stages and a last one for the final assessment of the diagram that classifies the different shades of innovation. During the time lapse between the four focus groups, observations and semi-structured interviews have been conducted through induction-deduction cycles in which the data collected from the experience and the dialogue within the organizations has been interpreted from time to time.

The semi-structured interviews, conducted face-to-face with the key informants, lasted between 45 and 60 min.

Starting from the two *RQ*s and from the classifying criteria identified in the literature review, then coded and re-categorized in the first two phases of the analysis, two interview sketches (Appendix) are elaborated (*categorizing* and *conceptualizing*). The protocol is based on some topics that guide researchers, which make the interviewees feel free to introduce new or unexpected elements and that encourage the emergence of new issues, experiences and questions (Addeo and Montesperelli, 2007). Each researcher recorded and transcribed the interviews autonomously and then shared the results with the others to reach a common interpretation.

The researchers decided to stop the analysis once theoretical saturation (Glaser and Strauss, 1967) has been reached. As recommended for single-case studies, primary data were triangulated with multiple sources of secondary data to increase robustness and quality (Yin, 2013).

3.2 Data collection and analysis

The research process involves four rounds of data collection and analysis: connecting; coding; categorizing; and conceptualizing.

Firstly, in the *connecting* stage, the research group formulates the research questions. Then, based on the key objectives of the work, the context of study is analyzed for a preliminary evaluation performed through secondary data and documentary analysis to assess the suitability of the case and detect the main actors and activities of the cluster.

The researchers established a first contact with the main representatives of the firms and institutions in the cluster at the "Smau 2018" event in Naples on innovation and technology. Then, the main representatives of the companies that participated in the event have been asked to join the research project. Out of the 23 partners of the Cluster contacted, the members from 11 organizations decided to participate (as reported in Table 2).

The first focus group has been planned at the University of Salerno at the end of December 2018 with the main suppliers, sub-suppliers, institutions and research centres in the sample to explain the research design and assess the main innovation goals of the Cluster. The second focus group has been performed one month later to investigate the context of study and collect data on the different partners, on their role and activities in the network to guide the mapping and identify the first guidelines to classify actors.

This stage has been realized through induction, as the emergent insights used have been gradually reconnected with research aims to enrich the objectives and to define the context of the study and gain information on the network's layout.

The second phase (*coding*) introduces the observation within the organizational contexts (sub-divided into groups of four firms-institutions for two researchers and of three firms-institutions for the last one), in which the experience of researchers in a period of two months (February–March 2019) contributed to the reconnection of the data collected with results for *RQ1* (deduction from data to theory). The first results obtained from semi-structured interviews have been corroborated (from results to new data to new theory) to classify and categorize the findings into some recurring sub-dimensions (archetypes). Thus, the transition from induction to deduction permits to detect regularities in actors' and organizations' behaviours and to attain the key findings for the *RQ1* by means of a data-driven description of pattern codes (for instance, the main activities of sub-suppliers are identified and named with a label, that can represent a new concepts for literature).

In the *categorizing* phase, the codes are interpreted by identifying key themes and extracting from them fewer units of analysis (categories and subcategories), through comparison of similarities, for the definition of some recurring elements that "fill" the archetypes with real results from the different companies. The results are integrated with the execution of a focus group (April 2019) to assess the validity of the interpretation of researchers (for instance, the renaming of the main activity of sub-suppliers is derived from the analysis of the archetypes, depending on the specific resources shared and the specific tools used, etc.).

Then, in the *conceptualization*, the results obtained are enriched with new observation and the administration of new semi-structured interviews from May to July 2019.

Table 2 Actors of national technology cluster for aerospace included in the sample

System	Market	Name of the company/ institution	No. of interviewees	Role	Composition
Regional clusters	Aerospace, defence and aeronautics	Regional cluster 1	2	President Cluster Manager	30 members (19 firms, 11 institutions)
		Regional cluster 2	2	Cluster Manager ECCP responsible	18 members (11 firms, 9 institutions)
		Regional cluster 3	1	Cluster Manager	275 members (250 firms, 25 institutions)
Suppliers	Aerospace, defence and security	Supplier 1	3	General Manager Technology and Innovation Manager Security & information system manager	Revenue: €12.240m Employees: 47.000 (15 countries)
	Propulsion systems for space and satellite	Supplier 2	2	Project manager Division Process Leader	Revenue: €344m Employees: 838
Sub-suppliers	Components for Aeronautics (composite tooling design, aeroengine structure design, aircraft furnishing)	Sub-supplier 1	2	Design engineer IT Manager	Revenue: €11.36m Employees: 160 (Italy, Turkey)
	Braking systems for vehicles	Sub-supplier 2	1	Aeronautics Marketing Manager	Revenue: €2.640m Employees: 10.634
Complementary suppliers	Satellites, space probes, space observatories	Complementary supplier 1	2	Information System Manager Telecommunication engineer	Revenue: €2.2bn Employees: 7,346 (Italy and France)
	Satellites services and communication, geo-information	Complementary supplier 2	1	Innovation and technological governance	Revenue: €257.10m Employees: 2.500
Public administration		Regional Council 1	2	Council Member for Innovation	Employees: 5.133
		Regional Council 2	1	Council Member for Infrastructures	Employees: 2.734
Non-profit organizations		Non-profit organization for Aviation	2	Head of Information systems department Head of Security department	Average budget: €210.3m Employees: 838
University		University 1	3	Head of Informatics department Head of Technology Transfer Head of Research department	Students: 40.000 Employees: 1.607
		University 2	2	Head of Informatics department Head of Research department	Students: 43.444 Employees: 1.485
		University 3	1	Head of Informatics department	Students: 29.255 Employees: 2.315
Research centres	Research Council for the Support of scientific and technological research	Research centre	2	President Head of Engineering, ICTs and technologies for environment and transport Department	Average budget: €900m Employees: 8,400
Users	Defence and safeguard of market, healthcare, energy, transport, education, food, sustainability and environment	Consumer Association for environment defence	2	Head of Studies, research & Innovation department Institutional relationships responsible	150 offices

Source: Our elaboration

The categories obtained in the previous phase are reinterpreted to obtain the conceptualization of different innovation types (*RQ2*), depending on the different combination of the enabling dimensions investigated (*RQ1*). A transition from deduction (coding) to induction (new data that unfolds new concepts) and, again, to deduction (identification of categories) is performed based on new observation (starting from the new goals deriving from the results obtained) and the subsequent administration of semi-structured interviews.

A final focus group has been held in September 2019 to discuss and validate the innovation diagram obtained (Figure 2) with the key informants and institutionalize the new typology of innovation proposed. Then, between October and November 2019, researchers re-interpreted the findings and reported them in the current paper.

A variable-oriented strategy (Miles and Huberman, 1994) guided the analysis: the continuous re-modelling of the classifying criteria (actors, activities, tools, etc.), enriched step by step, enables the interpretation of the results and the comparison between the different systems' elements, interaction patterns and innovation outcomes.

The data obtained from field research have been triangulated with secondary data (reports, documents mainly from websites) in each phase to reduce any bias, assess validity and to keep the observation updated with new questions and issues arising from the ongoing process.

Following mid-range grounded theory, conceptual models are developed throughout the analysis (for *RQ1*, see Figures 3–6, for *RQ2* see Figures 7) and a final diagram (Figure 2) is realized to display the findings, enhance generalizability (Colquitt and Zapata-Phelan, 2007; Yin, 2011) and to provide a scheme that can connect theory with practices (Gummesson, 2017).

Overall, as described in Figure 8, data design, collection, analysis and interpretation lasted 11 months, from December 2018 to November 2019.

4. Findings

4.1 Connecting

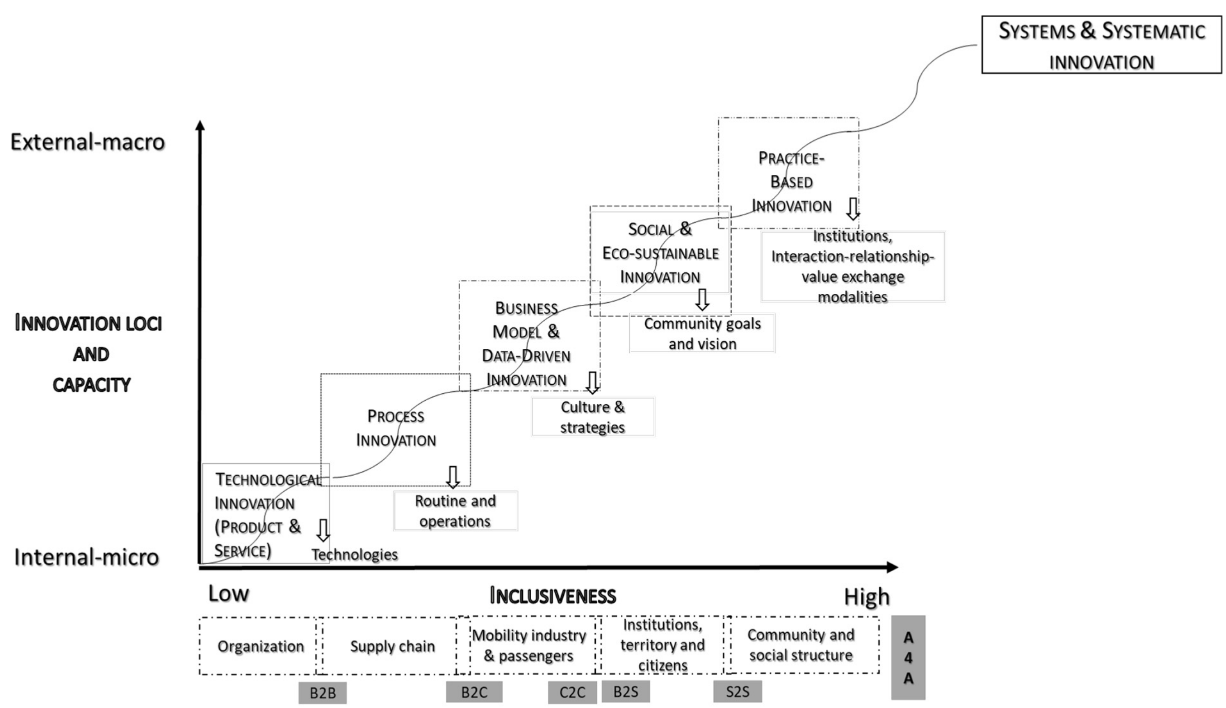
The Italian Cluster for Aerospace Technology connects the key players of the national aerospace system and acts as a catalyst and point of convergence of the different needs and requirements of the varied stakeholders to strengthen the competitiveness of the entire segment.

The data obtained from the focus group permit to classify the main actors of the Cluster and to sub-divide them into four main systems, depending on the kind of stakeholders involved and on the nature of connections (Figure 9): supplying systems (B2B and B2C); aerospace and general mobility industry (B2B and B2C); final users/citizens (B2C and C2C); public administration and non- profit organizations [business-to-stakeholder (B2S) and stakeholder-to-stakeholder (S2S)].

Suppliers are key actors producing main goods and services for aerospace, space, military and human transport aircrafts, intelligence and defence services. They are connected with three different systems:

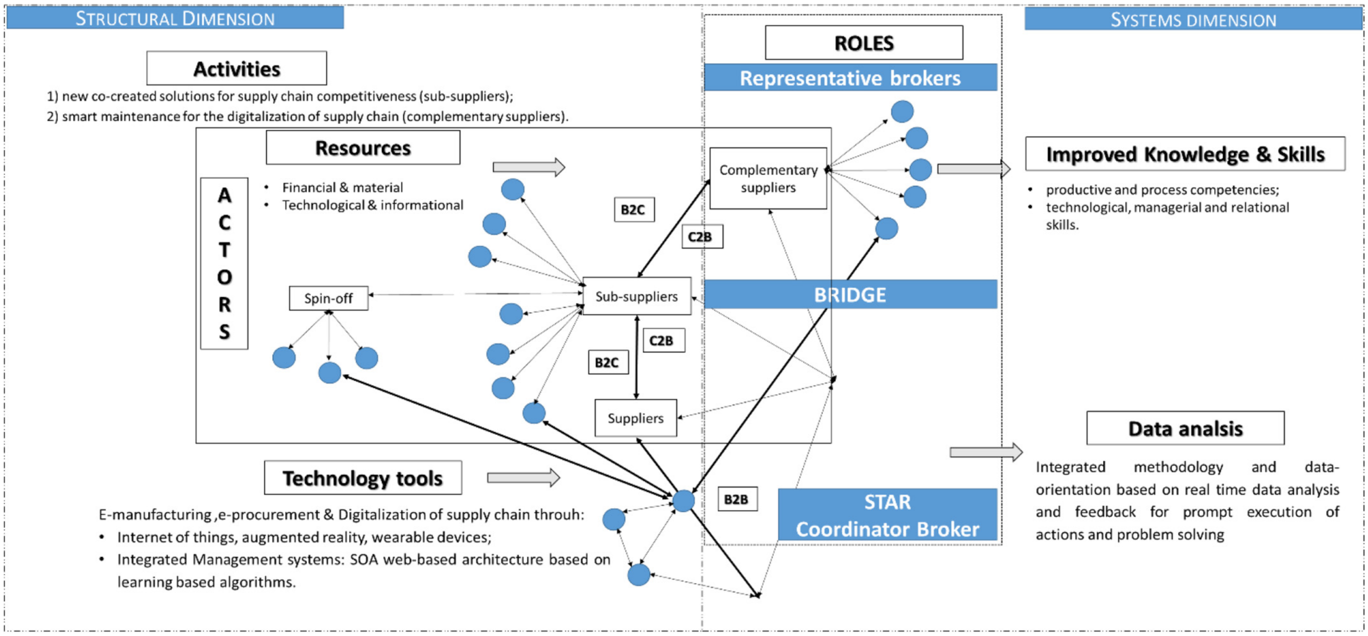
1 sub- suppliers: firms or spin-offs that provide components and/or offer single business function for aerospace and aeronautics;

Figure 2 Different shades of innovation for the emergence of systems and systematic innovation



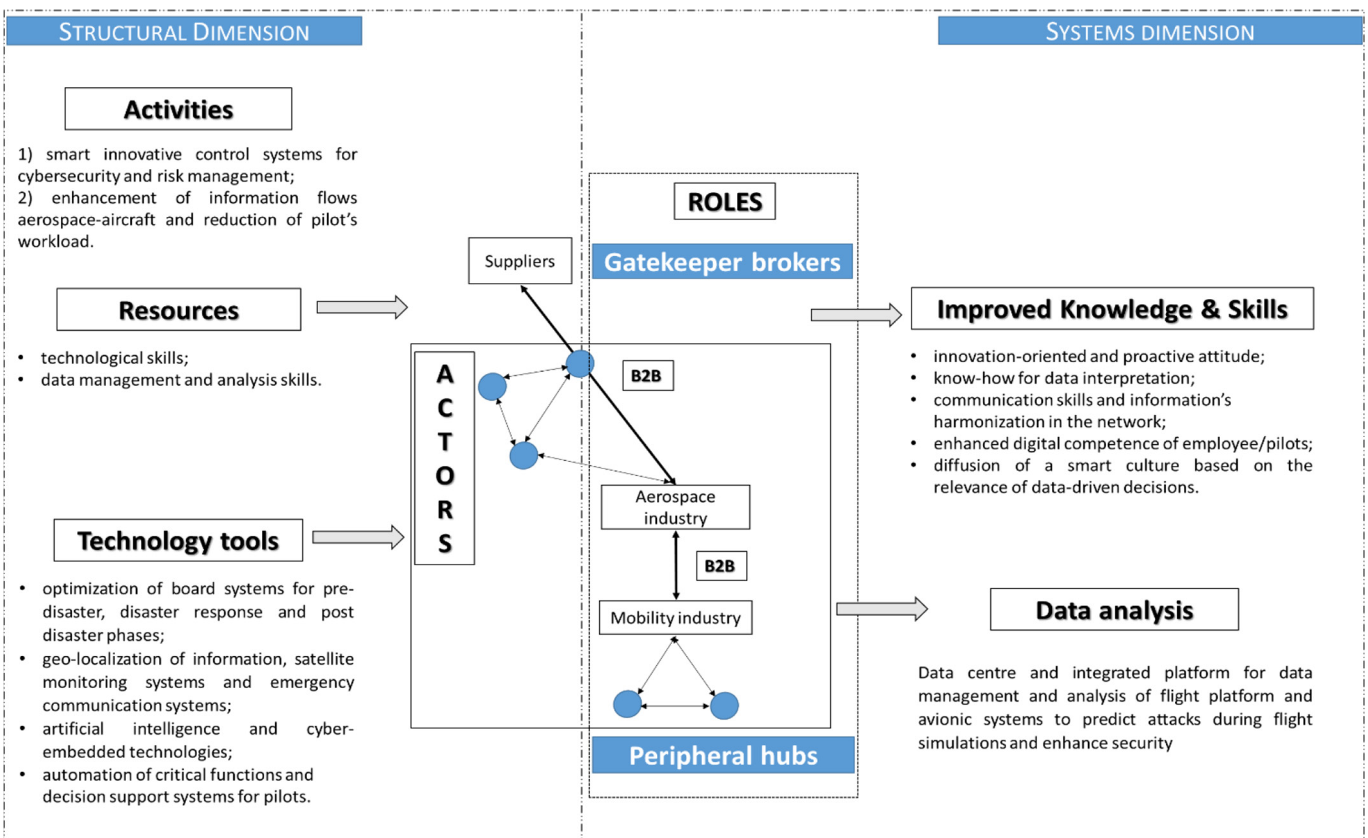
Source: Authors' elaboration

Figure 3 Supplying system: structural and systems enabling dimensions of innovation



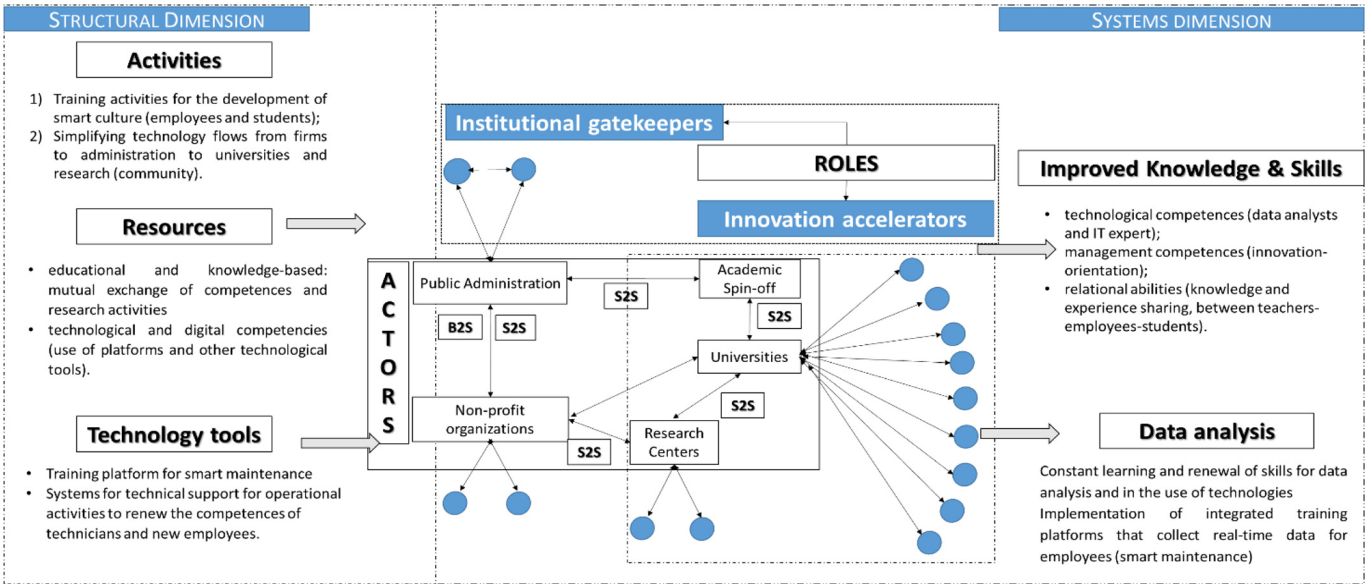
Source: Authors' elaboration

Figure 4 Aerospace and mobility industry: structural and systems enabling dimensions of innovation



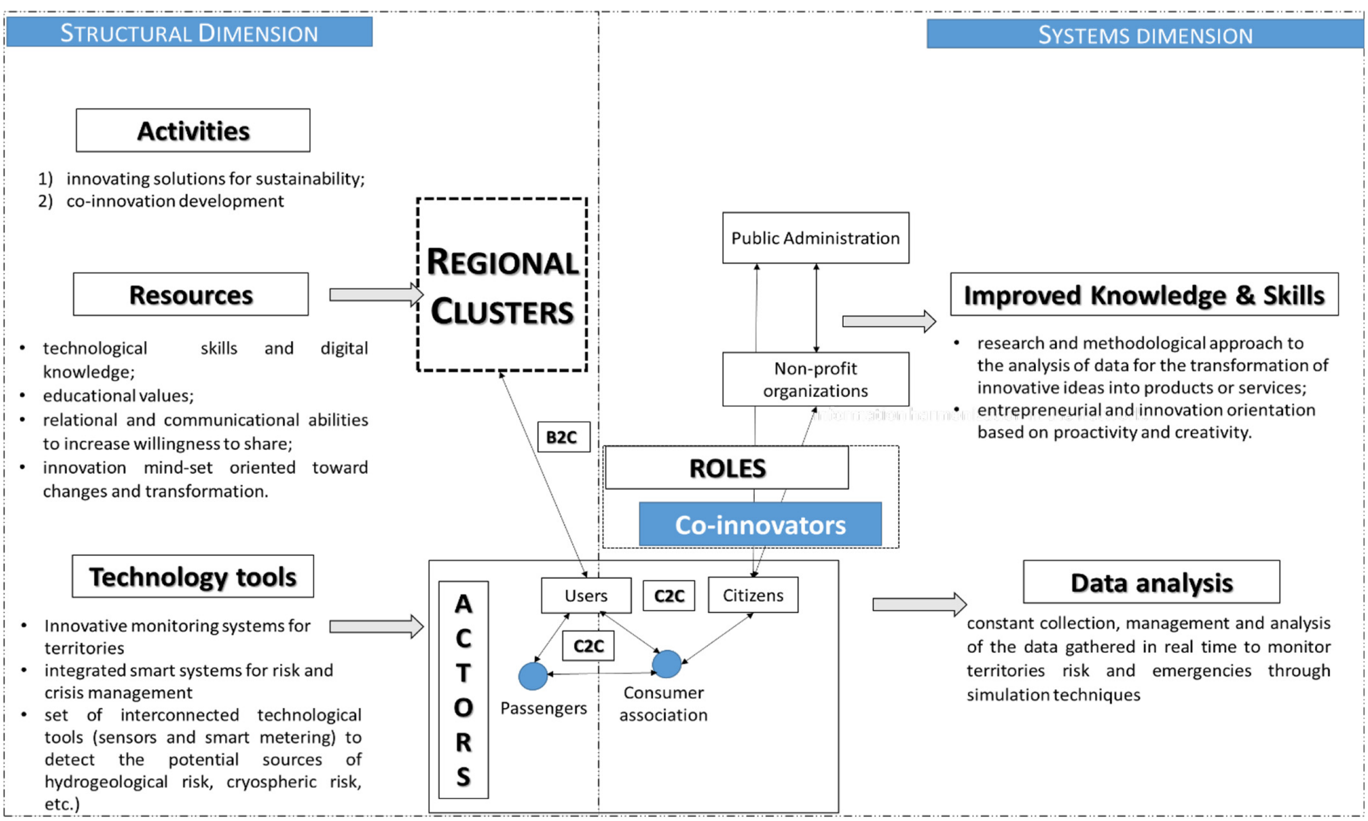
Source: Authors' elaboration

Figure 5 Public administration, non-profit organizations, academic and research system: structural and systems enabling dimensions of innovation



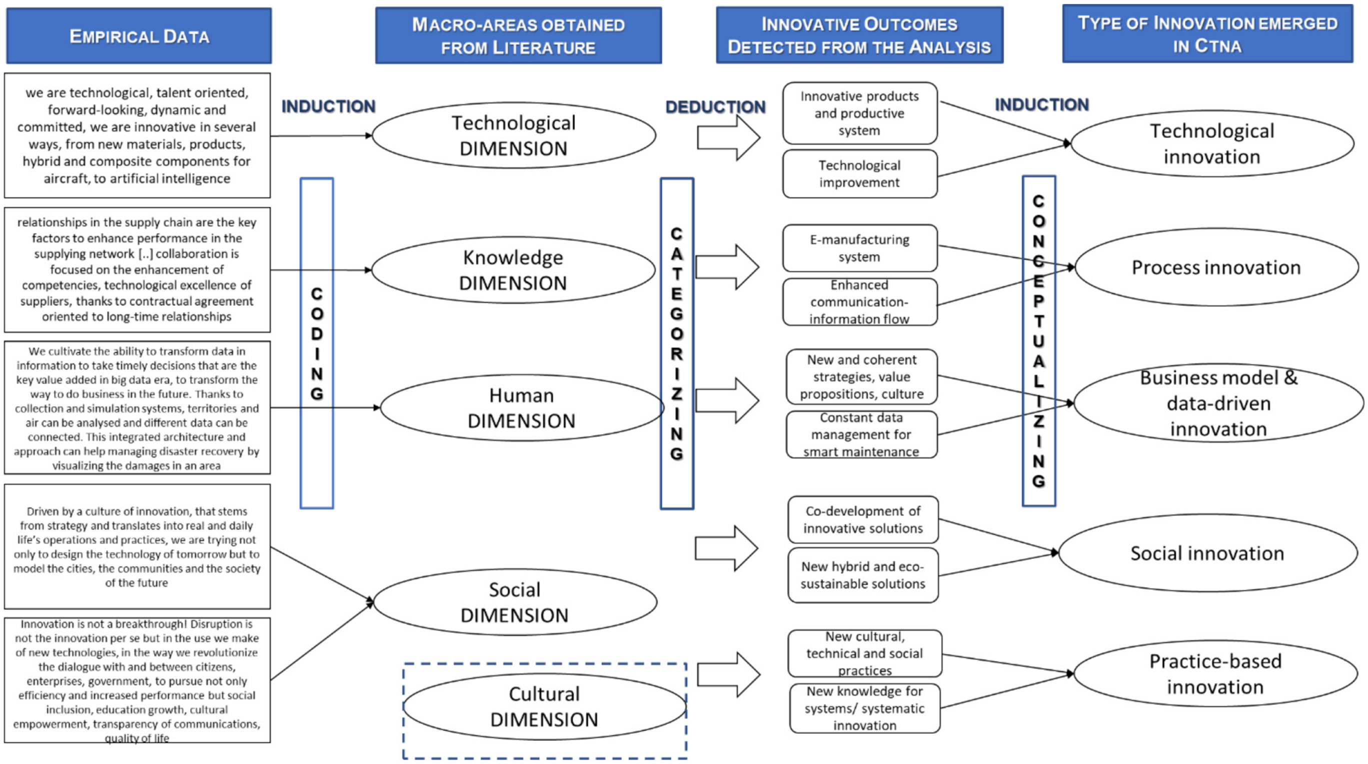
Source: Authors' elaboration

Figure 6 Users/passengers/citizens: structural and systems enabling dimensions of innovation



Source: Authors' elaboration

Figure 7 Conceptualizing the different shades of innovation: the findings of the different research phases



Source: Authors' elaboration

2 complementary suppliers: firms specialized in collateral services, such as telecommunications, satellites services (monitoring, communication), geo-localization, etc;
3 aerospace and general mobility industry: the entire market comprising other companies operating in aerospace and mobility (railways, buses, aircraft, etc.).

The regional clusters and the suppliers have relationships with users, who can be intended as customers/passengers (B2C) or citizens acting in the Cluster through consumer associations [customer-to-customer (C2C)].

B2S contexts concern the activation of relationships between the regional clusters and:

- public administration (Minister of Research and Education, regions and regional councils, municipalities, etc.);
- non-profit organizations;
- universities and academic spin-offs;
- research centres.

4.2 Coding and categorizing

The data obtained from the connecting phase have been re-elaborated by researchers and reconnected to the theoretical aims and to the literature. Then, some macro-variables are identified to guide the next steps of the analysis, to reveal the main enabling dimensions (*RQ1*) and how these are combined (*RQ2*) to produce innovation.

The key variables introduced between the coding and categorizing phases are the abstractions of the main archetypical elements of service systems that act as enabling dimensions for co-created innovation. In detail, as Figure 10 shows, according to a synthesis perspective, the traditional dimensions of analysis of service systems are reframed through some overarching categories that can be summarized through the following assumptions:

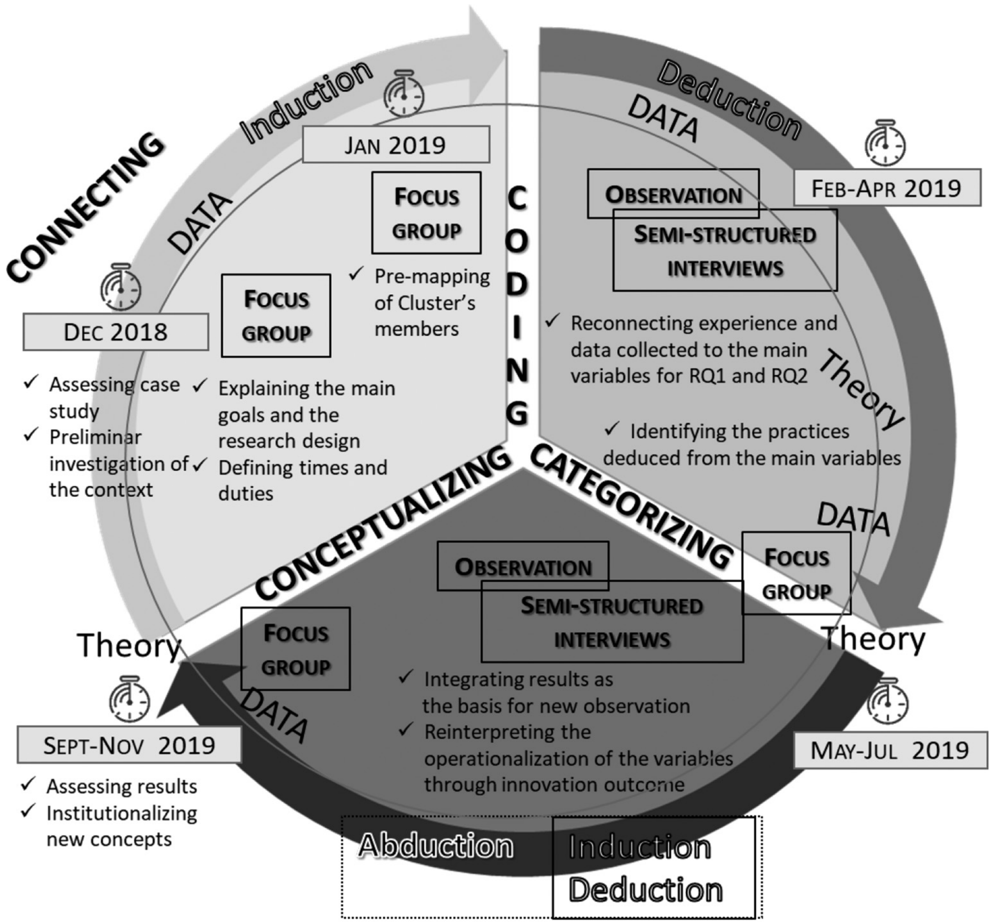
- providers/organizations and users/people are co-creating *actors* that share and integrate *resources* to perform different *activities*, boosted by the intensification of the points of contact or technological channels (*tools* that range from ICTs, to platforms and software);
- information in the systems is shared through immediate communications that permit to collect and analyze data (*data analysis*) that, through the application of renewed *knowledge* and *capabilities*, can be turned into value to be converted into insights and new value. The renewal and institutionalization of the innovative outcomes and values over time can transform actors into performers of given social *roles*.

Therefore, as depicted in Figure 11, the main archetypes identified are:

- actors, activities, tools, and resources (structural dimension);
- knowledge and capabilities, data analysis, roles (systems dimension).

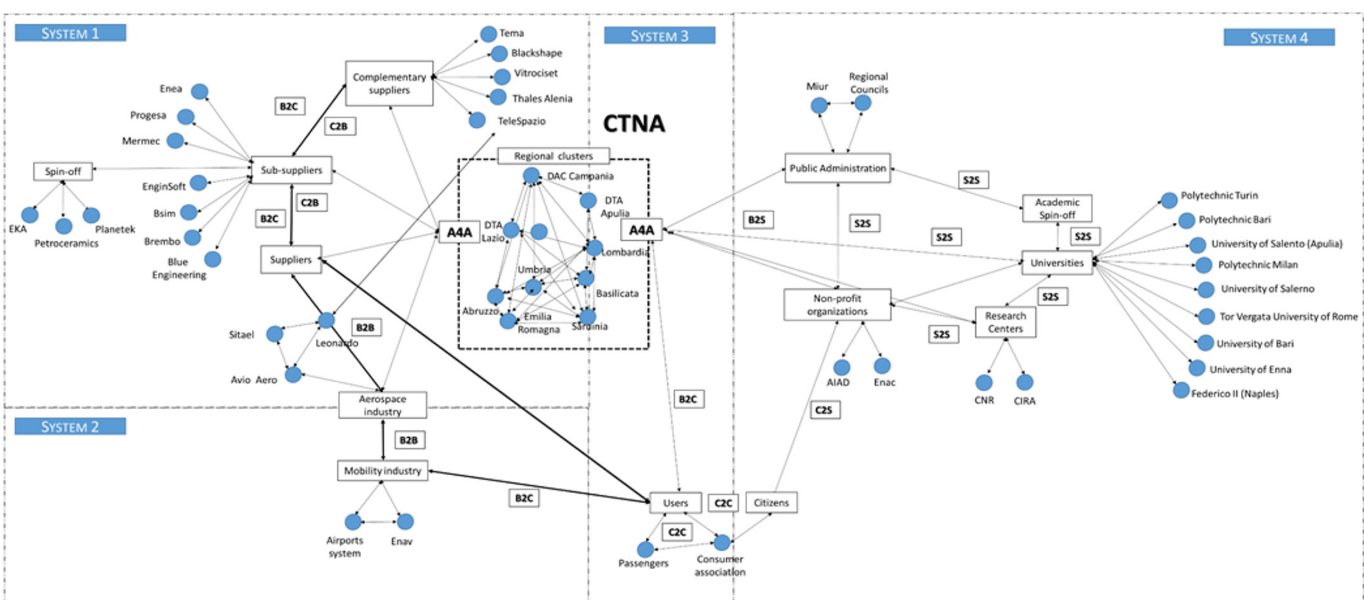
The dichotomy structure-system is borrowed from systems theories (Von Bertalanffy, 1968) and, in particular, from *viable systems approach* (VSA, Barile, 2006), Barile and Saviano, 2006), as it can be considered suitable for the investigation of

Figure 8 The different phases of the research design



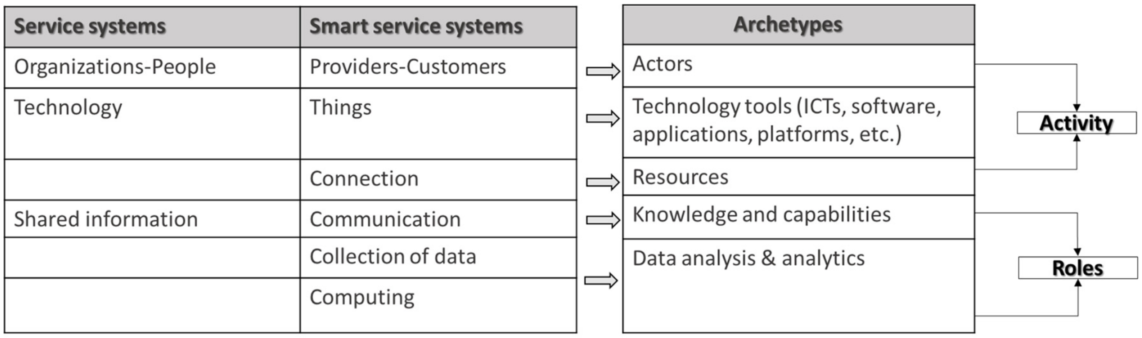
Source: Authors' elaboration

Figure 9 Mapping the main kind of systems and relationships embedded in National Technology Cluster for aerospace



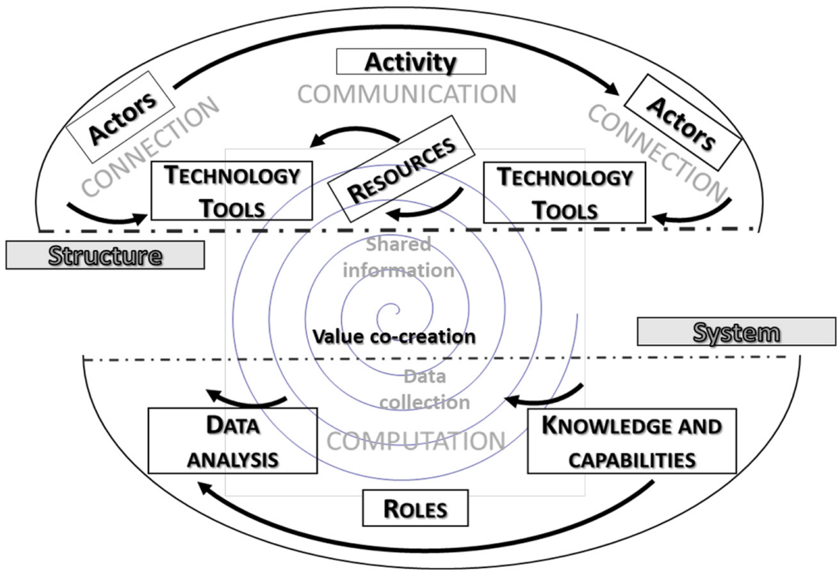
Source: Authors' elaboration

Figure 10 Identification of archetypes for the analysis



Source: Our elaboration

Figure 11 Identification of archetypes as intermediate categories of analysis



Source: Authors' elaboration

the transition from the arrangement of some organizational factors to their real activation and dynamic combination to pursue value (Kieliszewski and Anderson, 2019).

The analysis of the structural dimension aims at identifying the "who/which" dimension by detecting the kinds of *actors* that exchange *resource*s through given interaction modalities (B2B, B2C, C2C relationships) mediated by *technology tools* (platforms, software, ICTs, applications, etc.) to realize some *activities*.

The examination of the systems dimension seeks to reveal "how" the structural elements can be activated systemically to give birth to the dynamic exchange of *knowledge* and *capabilities* that are applied to the *analysis* of the data shared to extract insights and become – at the end of the process – interconnected *roles* performers.

4.3 Conceptualizing

The data collected in the last step of the research are analyzed and interpreted by reconnecting the results obtained to the archetypes (as intermediate categories) identified in the previous step. Then, new theoretical conceptualizations (*conceptualizing*) are developed:

- the specific structural and systems enabling dimensions of innovation activated in the different kinds of contexts and relational patterns in the Cluster (Figures 3-6);
- the varied innovation outcomes from the dynamic combination of the enabling dimensions (Figure 7).

Each researcher coded, categorized and classified independently the data extracted in the first two stages through qualitative content analysis for conceptualization. Next, consistency checks and comparisons between the different coding, classifying and conceptual schemes are performed to identify discrepancies and attain a unique and final framework (Figure 2).

To meet theoretical aims, in the description of the findings the main relationships in the network are subdivided into four patterns, that correspond to the different mechanisms that connect the four systems described above. In each group, the enabling dimensions of innovation (different actors, tools, activities -structural dimension- and resources, knowledge-skills, data analysis, roles -systems dimension) that shape different types of relationships (B2B, B2C, C2C or B2S) are explored (*RQ1*, Section 4.3.1). However, in the transition from structure to systems and in the detection of innovation emergence (*RQ2*, Section 4.3.2), a synthesis and A4A (*actor-for-actor*) view is adopted to take into account the synergy deriving from the patterns as an all-encompassing process.

4.3.1 RQ1: structural and systems analysis

4.3.1.1 Supplying systems. The first "section" of the cluster refers to B2B relationships between and among aerospace suppliers, sub-suppliers and complementary suppliers.

The main goal pursued is the enhancement of competitiveness of the entire aerospace sector aimed at developing innovative materials and integrated strategies for supply chain management that harmonize the relationships between producers of the main products and services and suppliers of components and collateral services by means of smart technologies.

Therefore, the activities performed by the actors can be grouped into two sub-activities: the development of new co-created solutions to boost supply chain competitiveness (sub-suppliers); smart maintenance, through the implementation and the wise use of innovative technologies that improves information flows through the digitalization of supply chain (complementary suppliers).

Regarding the first sub-activity (*co-development of new solutions*), the close connection between suppliers and sub-suppliers determines the advancement of three co-developed production systems and components:

1 propulsion systems (diesel, hybrid) alternative to the traditional internal combustion engine;
2 low cost composites (design and manufacturing technologies);
3 new "brake by wire" braking systems.

The Aeronautics Marketing Manager of sub-supplier 2, engaged actively in the development of braking systems (together with the two suppliers in the sample), declares:

> Our collaboration and the production of new temperature resistant materials for processes reduce time and costs for the delivery of aeronautical and industrial components [...] We try to realize a professionalized supply chain that promotes made in Italy to compete on international markets, since aerospace cannot be exclusively territorially-based and should depend on global logics.

The second sub-activity (*smart maintenance and supply chain digitalization*) involves the active intervention of complementary suppliers that help elaborating a platform for smart maintenance, composed of an integrated set of tools that:

- reduces and simplifies workload;
- enhances information flows in the supply chain;
- improves MMI infrastructure (man-machine interface).

The IT Manager of sub-supplier 1 states:

> The building of a general maintenance system for the suppliers in the Cluster is realized by means of immersive technologies, augmented reality, wearable devices [...] In particular, one of our last projects allowed the creation of an iterative simulation model that combines information in real time to encourage the attainment of logistic strategies.

The integration of the two sub-activities (*co-development of new solutions and smart maintenance for supply chain digitalization*) reshapes the interaction modalities between suppliers, sub-suppliers and complementary suppliers through an integrated system of technological tools for *e-manufacturing* that contributes to reduce costs, increase productivity and improve the relationship *human-machine*. The system enhances not only production processes but also permits to reduce the asymmetry between actors by empowering information sharing.

One of the Telecommunication engineers of complementary supplier 1 confirms:

> The combination of data on health monitoring, fleet management, depot (waste rate) and logistics (procurements, lead time) minimizes the impact on fleet operations, reduces costs and optimizes stock management. At the same time, the study of the man-machine interface and infrastructure helps improving the execution of validation sessions by end users.

Thus, regarding the systems dimension of data analysis, the firms engaged in the network not only implement an integrated architecture but determined also a shift in their orientation, which has been revised to include data management and interpretation upward business strategies. As declared by the Information System Manager of complementary supplier 1:

> beyond the technical and technological improvement of processes, we seek to build an integrated methodological approach that can realize a set of algorithms and applications to analyse data and to monitor the state of orbiting platforms through learning based algorithms for anomalies detection.

The platform is grounded on the elaboration of automatized controls that adopt learning-based algorithms comparing the normal functioning of satellites with the state of anomalies to foster predictive analysis for maintenance.

The data collected in real time are, then, shared directly with each actor that can detect the emergence of problems and an address them instantly. According to the Security & Information System Manager of supplier 1:

> "from data analysis results we know the most relevant and urgent actions required, for instance new tasks based on the levels of stocks or on the results of flight trials[...]by automatizing these requests, we and our stakeholders know immediately when actions are needed".

The resources exchanged to perform the sub-activities discussed above are, on the one hand, financial and material, and, on the other hand technological (IT and ICTS integrated) and informational. The first kind of resources concerns the economic and financial assets that support the launch of new products, together with the incentives and credits access for the small enterprises that start collaboration with big companies. Moreover, the enhancement of supply chain competitiveness can determine an increase in the employment systems, by producing economic opportunities for the job market. The second kind of resources are the technological skills and competencies offered mainly by complementary suppliers that contribute to the enhancement of data culture in the cluster.

The synergistic exchange of resources produces the enhancement of skills and the provision of new knowledge for the actors involved. These increased skills refer mainly to the improvement of productive and process competencies, together with the acquisition of technological, managerial and relational skills. The key players are provided with more knowledgeable competencies on process and on the opportunities offered by technologies. In turn, the development of new technological skills can increase digital culture, the ability to manage relationships, to communicate efficiently with partners, to perform the functional integration of competencies and can boost managements' orientation to smartness and innovation.

Finally, the diverse stakeholders involved in the supplying system perform different roles. The key supplier in the cluster can be considered as a "star", the hub with most relationships in the network, connected with every sub-system. Strategically located, this firm contributes to the stability of the cluster and to the attainment of shared goals. The central localization makes this hub a broker, which transmits and coordinates information flows, manages relationship and shapes communication modalities to reduce asymmetry. As noticed above, the biggest companies in the Cluster provide also small and medium enterprises with economic incentives and with support for the attraction of public and private funding. The star acts as a catalyst for initiatives that can be brought successfully to the market by also giving an international dimension to projects.

Sub-suppliers can be considered as strategic partners that provide high technology services and specialized know-how. Since they connect the other actors with sub-systems that are not related to other member of the network (spin-offs), they can be considered as bridges (between suppliers and spin-offs and between suppliers and complementary suppliers). Complementary suppliers are specialized representative brokers that have the main task to provide the external systems (suppliers and sub-suppliers) with the specific competencies developed within their organizations (skills related to telecommunications and localization systems are not owned from the other members).

Figure 3 synthesizes the results reported by classifying the structural and systems enabling dimensions activated in CTNA supplying system.

4.3.1.2 Aerospace and mobility industry. The strategic collaboration between suppliers, aerospace system (other firms that operate in aviation, aircraft, civil and military aircraft and aeronautics) and mobility (railways, buses, boats, etc.) system is oriented towards the building of stable relationships. A key role is played by technologies, aimed at improving inter-cluster partnerships and at promoting the aerospace and aircraft segments, with positive impact on mobility sector.

Two sub-activities can be identified:

1 development of smart innovative control systems for cybersecurity and risk management for the prevention of aircraft disasters;
2 enhancement of information flows and reduction of pilot's workload.

Both are pursued through the creation of a smart management system for aircraft traffic that, on the one hand, monitors air status and detects potential emergencies and, on the other hand, enhances the communication between operators and pilots. This system is based the building of an integrated set of enabling technology tools that consists of:

- *Remotely piloted aircraft systems (RPAS)* for surveillance and information gathering;
- innovative elements in the flight control systems (*inceptor*) of aircrafts;
- simulation methodologies for the validation of the new flight control system.

Regarding the first sub-activity (*cyber security and risk management*), through a joint project, the Cluster advances the optimization of board systems for management of pre-disaster, disaster response and post-disaster by adopting geo-localization of information, satellite monitoring systems and emergency communication systems based on broadband space assets. The management of emergencies and cyber threats is supported with the automation of critical functions and decision support systems for pilots by means of artificial intelligence and cyber-embedded technologies.

As confirmed by the Security and Information System Manager of Supplier 1, the platform

> realizes a 360 degree protection through the implementation of an integrated hardware and software systems for the Connected Aircraft that uses layered security measures to deliver multifactorial authentication, encryption and data integrity.

The second sub-activity (*reduction of pilot's workload*) is obtained through smart territory monitoring and general aviation and primary training (for instance, international flight training schools for military aeronautics). One of the key areas of intervention is the proposition of components to define the interface between the aircraft model (information on thrust and fuel consumption) and the power train (information on the flight state) to enhance information flows between the platform and the pilots. The reduction of pilot's workload is attained through the simplification of interactions with on-board systems in the cockpit, through the enhancement of safety and preventing of critical areas.

The resources exchanged between and among the actors involved are technological and related to the provision and sharing of sophisticated information systems and of data management and analysis skills. Thus, the enhancement of digital competencies in the whole market and of employees/pilots is pursued through the diffusion of a smart culture based on the relevance of data-driven decisions.

According to the chief of technology and Innovation of supplier 1, a "data centre" is realized for both the sub-activities to analyze the vulnerability of flight trials and provide reports on risk estimate:

> an interconnected smart system predicts risks and enhances data flows constantly to improve synergy between aerospace, aircraft and mobility sectors [. . .] to develop an end-to-end strategy for cybersecurity and extend protection from providers to employees and, then, passengers.

Resources exchanges foster the improvement of actor's managerial capabilities to catch insights from markets, from customers and employees through real-time collection and analysis of data on flights. In this way, the development of an innovation-oriented and proactive behaviour is promoted. Moreover, some technical skills are acquired, related to the enhancement of know-how in data interpretation and communication skills are improved through the strengthening of the capabilities to harmonize information in the network.

Finally, as Figure 4 shows, it can be noticed that the role of suppliers in the relationships with aerospace and mobility industry is different from the role performed in the management of supplying systems. Suppliers can be intended as gatekeeper brokers, as they connect to the cluster two different systems (aerospace and mobility industry, which otherwise would be unconnected) but they share the same skills, resources and productive processes only with one of them (aerospace industry). The task of gatekeepers is to encourage the acquisition of new knowledge from the external.

Aerospace and mobility systems can be considered as peripheral hubs since they are connected indirectly with the other systems in the cluster (such as sub-suppliers and complementary suppliers) and establish with them less frequent interactions. However, despite the marginal position, they offer key resources such as compliance, legitimacy in the market and strategic insights on the requirements advanced by final market, as they are connected directly with passengers (Figure 9).

4.3.1.3 Public administration, non-profit organizations and universities. The regional clusters included in CTNA, public administration, non-profit organizations, universities and research centres work together within a network of businesses-to-stakeholders relationships (BtoS) for the enhancement of the well-being of the entire cluster by promoting training activities for: organization's members; students; citizens and community.

Regarding the internal human resources, the enrichment of the competencies of extant workforce and the creation of new professional figures (technicians, consultants and researchers) are pursued. For instance, a platform has been realized to combine virtual and mixed reality and to offer training for maintenance, operations and local technical and remote support for complex systems and components assembly. The goal is to offer a totalizing training experience, oriented to the simulation of maintenance and operational activities that technicians and new employees are required to learn. These activities do not increase only future employees' skills but contribute also to raise the engagement of extant workers and employees, with high rate of job satisfaction. One of the employees of a key supplier in the network affirms:

> I joined the company ten years ago, expecting to stay for two or three years, to make training and leave [...] but now I don't' want to leave, since we cultivate a culture based on constant training, mentoring, coaching, we solve the challenges together, we created a link between universities faculties and our business departments.

The cluster proposes every year a series of training activities that engage students from universities, high school, and secondary schools. For instance, the annual Scientific Youth Conference provides children with the possibilities to develop scientific knowledge on aerospace and to increase their interest in science, technology, engineering and mathematics. Moreover, they can learn how to work in teams and how to speak in public by experiencing the life of researchers.

The Head of Technology Transfer from University 1, that supervised the project, declares:

> I followed a series of laboratories with children to develop their creativity in which we teach the story of the inventions in the past or some basic notions on programming [...] I learn from them, I bring with me the enthusiasm and the motivation to keep on doing this job". Thus, as stated by one of the Council members in the Cluster, "collaborations with research centres and University help developing distinctive competencies in data analysis and in the use of technologies and can enhance not only students' skills but can help also teachers being more focused on the real problems of daily life.

Training activities and the improvement of skills are pursued also in the community to simplify technology flows from firms to administration to universities and research. In detail, training and innovation projects are developed together with the provision of courses, masters, specialized schools, PhD courses and traineeship for the preparation of highly qualified technicians, researchers and technologists. According to the president of the research centre in the Cluster:

> the ability to integrate skills, competencies, know-how, territories, people harmonically is the real key for the attainment of sustainable competitiveness [...] We created a network of relationships but above all a network of brains that integrates the know-how of companies with academic culture to pursue a continuous innovative tension.

The key technology tools adopted to realize training activities are platforms for internal organizational members, new technologies and data analytics to increase the scientific and technological competencies of employees and students. Together with the enhancement of digital capabilities, the aptitude for data analysis is fortified to teach how to use the instruments offered from smart technologies efficiently and extract relevant values and new insights from data.

Then, the main resources exchanged in B2S relationships are educational and knowledge-based, on the one hand, and technological, on the other. Training is the common thread of interactions and it is realized through the provision of technology and digital competencies.

Consequently, the skills shared through educational activities are related to:

- technological competencies (data analysts and IT experts);
- management competencies, deriving from the diffusion of an innovation-orientation; and
- relational abilities (active sharing of knowledge and experiences, for both teachers and students).

In this way, the members of the community are provided not only with new skills on the smart use of technologies but also with a mind-set grounded on innovation that can help overcoming digital barriers and diffusing a smart culture.

Public administration and non-profit organizations can be considered as institutional gatekeepers, as they influence the determination of policies in the cluster and are influenced, in turn, from the informal rules established bottom-up by the different actors. Thus, institutional gatekeepers may reflect the dominant values of a given moment and based on these, can settle the guidelines for the activities, by readapting them based on the emergent rules arising from systems relationships.

Spin-off, universities and research centres are innovation accelerators that lead to the development of innovation processes and to the shared growth of community through the constant engagement in the development of new products/processes, research projects, technology transfer, patents. Figure 5 describes the main structural and systems enabling dimensions for innovation in the relationships with public administration, non-profit organization and research and academic system.

4.3.1.4 Final users/citizens. The regional clusters and the suppliers have relationships with users, that can be intended as customers/passengers (B2C) or citizens that act in the cluster through consumer associations for general mobility systems (C2C).

The interaction modalities between them are mediated through a set of tools that provides final users and citizens with innovative technologies aimed at preserving the eco-sustainability of products to enhance users' security, on the one hand, and at pursuing co-innovation.

The first sub-activity (*eco-sustainability*) aims at reducing the environmental impact in the entire lifecycle of goods and services through the proposition of hybrid/electric propulsive architectures, raw materials, processes for low energy consumption and advanced systems for smart maintenance. According to the Project Manager of supplier 2:

> the development of a network of varied skills and competencies, in which research centres and universities are engaged" permits the creation of "new materials and enabling technologies for efficiency and durability that safeguard the environment.

The cluster launches a series of environmental projects that:

> "tries to preserve territories and the people that live in them by trying to pursue a twofold aim, social and environmental, since preserving the planet and the quality of life are the first steps to promote territorial development"

As explained by the President of the research centre included in the sample.

The key technology tools used to support sustainability are smart sensors and monitoring systems that detect the potential sources of risk for territories (hydrogeological, cryospheric and related to the presence of volcanic dust in the atmosphere) and store and analyze data constantly to detect emergencies in real-time.

The second sub-activity (*co-development of innovation*) is performed through the spreading of an innovation orientation that encourages the proposal of ideas for new projects and services and through the active engagement of users and youngsters in innovation contests.

With the active support of supplier 1, the cluster organizes annual hackathons and innovation awards, two open innovation projects that connect the best talents from high schools and scientific faculties of Italian universities. Students participate in a challenge in which they should solve a business case by showing their problem-solving abilities and teamwork attitude with the constant supervision of consultants, experts in the field and mentors (PhD, university students, etc.). According to the Manager of Technology and Innovation of supplier 1:

> Hackathon is a tool that encourages innovation by boosting the complex transformation of ideas into concepts and new products [...] By interacting with students we can grasp how competencies evolve in contemporary world.

The close relationship between participants and mentors highlights that Hackathon is "a marathon of ideas" that can stimulate innovation from external sources by promoting, at the same time, internal competencies.

The involvement of users in innovation awards and contests fosters the exchange of educational and relational resources provided by mentors and shared in the relationships firms-institutions/employees/users. Moreover, a mind-set oriented towards changes and transformation is diffused by enhancing students' and citizens' digital knowledge that increases their competencies in the smart use of technology and enriches their innovations capabilities and willingness to share. To stress the relevance of an orientation to innovation, the Council Member from Regional Council 1 affirms:

> innovation is the best insurance policy we can agree upon to guarantee us a future at least equal to the past, that can help us to interpret the reality and to make things differently, not just in the way we develop the products but in the use we made of them.

Therefore, the strengthening of knowledge concerns mainly:

- the improvement of technological competencies, which raise the willingness to adopt and use technologies;
- the development of entrepreneurial and innovation orientation based on proactivity and creativity to boost the proposition of innovative services;
- the adoption of a research and methodological approach to data analysis and to the complex process that transforms ideas into business ideas and into real products or services.

The General Manager of supplier 1 declares:

> in what we do, we do not care only for firms and research, we care for youth, when they meet technology amazing things can happen [...] Exchange of views and discussion with youths is an accelerator of innovation for the entire Cluster, especially in a fast changing era in which innovation is a priority: the 19% of our patient portfolio derives from innovation award initiatives.

Therefore, users-citizens, that range from actual to potential employees to customers, are co-innovators, considered as innovation accelerators that, differently from public administration and non-profit organizations, share non-economic resources such as knowledge, creativity, experience and values to improve cluster's decision-making and participate in policy-making and in the co-development of sustainable innovation.

Figure 6 synthesizes the main structural and systems enabling dimensions identified in the relationships with users-passengers and citizens.

4.3.2 RQ2: the emergence of different kinds of innovation

The approach based on the cycle data-theory permits to connect the different novelties generated in the cluster, arising from the findings obtained to address *RQ1*, with the identification of different kinds of innovation modalities, conceptualized and submitted to interviewees that validate them.

As Figure 7 shows, firstly, in the *coding* phase the experiences collected (empirical data) are connected inductively to the enabling dimensions of innovation obtained from literature (more abstract macro-areas, see Section 2.2). Secondly, a new cycle of collection reveals new data that leads deductively to a re-categorization of the macro-areas into second-order categories (the specific innovation outcomes developed in CTNA), generated through the phase of *categorizing*. Finally, in the phase of *conceptualization*, some theoretical themes (the new concepts generated, that are the five different kinds of innovation) are obtained.

Based on the varied innovative features generated across the four sub-systems in the Cluster, five shades of innovation have been conceptualized through the implementation of a circular data analysis procedure that allows at obtaining and deriving two main variables, which helped categorizing the empirical data into different innovation patterns: inclusiveness; and capacity.

The capacity of innovation refers to the "range" of innovation, that depends on the *locus* in which newness is created and can range from internal sphere (micro: the development of new technologies or products related to single suppliers) to external sphere (macro: the creation of new institutions or social values for the entire community). Inclusiveness concerns the degree of involvement of the different actors in the cluster, which can be low (inclusion of suppliers from economic systems) or high (inclusion of public organizations, research centres, citizens and other social systems).

In this way, the innovative entities emerged in the cluster have been reframed as five shades of innovation:

1 technological innovation (technological dimension);
2 process innovation (knowledge-based dimension);
3 business model innovation and data-driven innovation (human dimension); and
4 social and eco-sustainable innovation (social dimension);
5 practice-based innovation (socio-cultural dimension).

Data analysis confirms the existence of the different enablers detected from literature and introduces a new kind of dimension, the *cultural* one that – mixed with the social sphere – can give birth to the development of new practices and to the most abstract type of innovation.

The different dimensions, categories and outcomes of innovation identified in the analysis of the Cluster are described below.

4.3.2.1 Technological innovation. Technological innovation concerns the introduction of new technologies for the realization of materials, components, products (propulsion systems) and services (satellites) and the enhancement of communication systems (IT and ICTs based systems for monitoring). It is developed by means of the joint research and between suppliers, sub-suppliers and complementary suppliers and refers mainly to B2B relationships and to the internal sphere of organizations.

As described in Section 4.2.1, the stable relationships in the supplying system give birth to the constant advancements in innovative production systems and components (from engine to manufacturing technologies to low-cost composite materials and braking systems), new propulsion technologies for aeronautical applications (engines for piloted aircraft) and space applications (microsatellites).

Together with innovative and hybrid materials (product innovation), the cluster proposes new technologies for communication (service innovation), which compose an integrated set of ITs and ICTs-based tools based on satellite telecommunication that enhances monitoring system for aircrafts geo-localization. Therefore, the creation of a system of technologies that supports and addresses the technological evolution of the market (RPAS, smart flight control systems, simulation methodology) can provide the cluster with the ability to renew products and services constantly, by pursuing systematic innovation and achieving sustainable competitive advantage.

The IT Manager of sub-supplier 1 emphasizes the attainment of continuous technological improvement:

> "We strive to produce new technologies and a rich heritage in technological innovation in the entire aerospace industry that will continue to attract high-specialized talents to enrich the heritage for the future".

4.3.2.2 Process innovation. The design and the production of innovative materials, components and structures for aerospace industry (technological innovation) are related strictly to the introduction of simplified and digitalized processes and, above all, of new standards to enhance operations, to optimize traffic and general mobility and to increase process security. The improved procedures to provide products and services of increased quality enable the simplification and the acceleration of the relationships between the supplying system (suppliers, sub-suppliers and complementary suppliers) and aerospace and mobility markets.

The active support of complementary suppliers fosters the digitalization of supply chain through smart maintenance systems based on new technologies (augmented reality, sensors, and wearable devices) that enhance: materials and products-service flows (*e-manufacturing*); information flows (communication between sub-suppliers and general mobility sector).

By developing new integrated strategies for supply chain management, from both material and informational standpoint, the competitiveness and the innovation potential of Italian aerospace sector is attained through costs decrease, performance enhancement and the improvement of human-machine interaction.

Thus, the degree of inclusiveness of the innovative outcomes produced in the cluster broadens to embrace the entire industry (pilots, other organizations in aerospace and mobility, national mobility agencies) and to enlarge the ability to develop and spread innovation beyond organizational borders. By confirming the adoption of a supply chain management strategy, the Information System Manager of Complementary Supplier 1 declares:

> "Relationships in the supply chain are the key factors to enhance performance in the supplying network [. . .] Collaboration is focused on the enhancement of competencies, technological excellence of suppliers, obtained from the establishment of contractual agreement oriented to long-time relationships".

4.3.2.3 Business model innovation and data-driven innovation. The enhancement and the optimization of information flows and materials across the supply chain (process innovation) enable the development of business model innovation that redefines strategies and goals definition, resources selection and relationships management according to a data-driven culture that pervades organizations. In this way, the emergence of newness all-encompasses the different dimensions of business models. New rules are generated to create value propositions (*strategy*, that is internalized and translated into cohesive *culture*), shared internally and externally (through *resources integration*) through optimized operations and relationships (*management*) and turned into new knowledge (enhancement of quality and *continuous improvement*).

The motivations that drive the process of change in business models are explained by the Project Manager of Supplier 2:

> With the diffusion of disruptive concept, especially in the business models of international players such as Boeing, we redesigned the model for relationships in our supply chain [. . .] Cross-fertilization between suppliers, start-ups, spin-offs and the academic world allows to pull together experiences to learn how to do things differently and to adapt to the fast pace of technological evolution in contemporary scenario.

This innovative mind-set connects the main elements of business models (strategies, resources selection, relationships management, etc.) by means of a data-orientation that fosters the complex transition from insights development to ideas generation to products realization and enables the transformation of data into information and, then, value or new value.

Data-driven innovation in business models can be intended as the result of the application of a new methodological approach to maintenance oriented to the constant data management to improve processes. The human intervention is essential to apply the right skills, competencies and methodological sensitiveness to data analysis.

In the cluster, smart maintenance is realized through the elaboration of an architecture that integrates the information shared from design and production departments to operations (in the single organizations) and across the different service systems (from sub-suppliers to suppliers related to stock management or in the communication from suppliers to mobility sector for traffic and passengers management). This approach is supported by the proposition of integrated monitoring systems and simulation methodologies, based on a data centre that predicts risks, enhances security and allows:

> "the constant collection, management and analysis of the data gathered from RPAS in real time to monitor territories and provide them with information on risk and emergencies".

The General Manager of Cluster 2 confirms the adoption of a data-driven approach in CTNA, deriving from the smart application of human skills:

> We cultivate the ability to transform data into information to take timely decisions that are the key value added in Big data era, to change the way to do business in the future. The implementation of collection and simulation system permits the analysis and connection of data on territories and air quality.

4.3.2.4 Social and eco-sustainable innovation. The development of new strategic orientation and (data) culture fosters (*social*) innovation that enhances, in turn, well-being and introduces new environmental (*eco-sustainable*) practices.

The strategic involvement of innovation and data-culture into business processes (business model innovation) translates into the creation of a varied set of innovation strategies that entails:

- the active involvement of research and academic system in the Cluster to provide human resources, students and citizens with new knowledge and to co-develop innovative solutions (*social innovation*);
- the advancement of new hybrid solutions to safeguard the environment (*eco-sustainable innovation)*.

Social innovation is developed through the proposition of new standards for education and models for learning and digital competencies. Through the collaboration with universities and research centres, innovation hubs and labs, the cluster aims at increasing the skills and the interest towards aerospace of extant and future employees, to promote scientific citizenship around the world. As declared by the President of the Research centre in the sample:

> "For us engineering is interesting, but we try to share this passion with the children and teenagers to increase their interest in scientific disciplines. We believe engineering can be exciting since it proposes new ideas and realize them, it is a way to give birth to creativity".

The key role of competencies helps the attainment of social purposes (digital citizenship and inclusion) but raises also the attractiveness of organizations as investors, as confirmed by the Manager of Cluster 3:

> We innovate by relying on young talents. We want the actors of the Cluster be considered as attractive employers that invest in people and competencies, to be catalyst for technological progress detecting and discovering the key technological areas of the future and trustful partners for local communities, by guaranteeing the financial stability of the industry.

The Innovation and Technology Manager of Complementary Supplier 2 reveals the all-encompassing nature of social innovation:

> "driven by a culture of innovation, that stems from strategy and translates into real and daily life's operations and practices, we are trying not only to design the technology of tomorrow but to model the cities, the communities and the society of the future".

Regarding environmental innovation, the cluster introduces new hybrid and low impact products and a smart system for territories to monitor global change and manage its effects to limit emissions of carbon through radars that improve meteorological forecast and spectrometers to monitor planet health and ozone. Sustainability can be considered as one of the key values of cluster's mission and as a strategic asset for most of the firms and of the institutions in CTNA. As confirmed by the President of the Cluster:

> "we want to play a key role in the society we live in and we belong to by assuming responsibility toward future generations. Sustainability is the thread that connects everything we do, we try to balance constantly resources we have and the external challenges".

4.3.2.5 Practice-based innovation. The "accumulation" of the different kinds of innovation described in the previous paragraphs generates technical, cultural and social practices (Storbacka and Nenonen, 2011) that can lead to the actors-driven diffusion of new rules for companies, institutions and citizens in the cluster.

The willingness to pursue an all-encompassing innovation is highlighted by the Manager of Cluster 1, who reveals the conscious adoption of a systems approach:

> "we are talent oriented and forward-looking; we innovate in several ways, from new materials, products, hybrid and composite components, to artificial intelligence [...] to combine dynamically four main value drivers: great people, innovative ideas, international client base, supportive supply chain".

Thus, the innovative outcomes generated can be transformed from material and technical outcomes (in technological innovation) into new orientation (in business model innovation) and into rules and institutions (practice-based innovation) to reach, finally, the highest degree of intangibility. The diverse types of innovation produced (from technology to social innovation) stimulate incrementally the generation of common institutions by simplifying knowledge exchange and dialogue between public and private users and new rules for actor's interactions, communication and data-collection.

Practice-based innovation reframes the innovative outcomes reached in the cluster at the maximum abstraction level, which is based on their institutionalization.

In detail, technical, cultural and social practices are generated from the introduction of new standards that can increase overall cluster's knowledge and can turn it into creativity and new knowledge to be institutionalized and renewed over time to pursue systems and systematic innovation. Technical standards refer to the diffusion of new accepted rules for production, processes and telecommunication systems implementation in aerospace sector. The cultural standards deal with the adoption of a proactive attitude for entrepreneurship and of an innovation-oriented mind-set for management. Moreover, a new culture based on data is diffused not only within the organizations, but is shared also with employees, students and citizens to enhance a digital culture based on smartness, technologies, social change. The environmental standards (for low energy consumption, sustainability of process, etc.) reframe the way in which mobility and environment are lived and experienced.

The new practices emerged in the cluster derive from the combination of human actions applied to technologies and from daily activities and collective sharing of knowledge among networks of individuals and organizations that combine tangible and intangible features to form and reform the new value and outcomes produced over time. The Manager of Cluster 1 explains the mechanisms generating these new standards and rules, which are obtained from the synergistic combination of the innovation outcomes described above:

> Innovation is not a breakthrough! Disruption is not the innovation per se but in the use we make of new technologies, in the way we revolutionize the dialogue with and between citizens, enterprises, government, to pursue not only efficiency and increased performance but social inclusion, education growth, cultural empowerment, transparency of communications, quality of life.

As reported by the General Manager of Cluster 1, the introduction of new rules derives often from bottom-up processes:

> At the beginning, in 2012, we had some problems with the regulation, which was so ineffective and vague. This prevented the development of the Cluster as a new systems entity [...] it was impossible that a productive sector like Italian aerospace and aeronautics, a technological excellence, cannot disrupt after the combination of the key players.

Not only the introduction of new rules can be actor-driven but also it can be the first step to encourage the intervention of the legal system: "our own strategy has been developed gradually and bottom-up. Then, only after our proposal, the normative regulation has intervened".

5. Discussion

The varied modalities (*RQ1*) of value creation described in Section 4.2.1, if combined properly, can give birth to a synergy superior than the single sum of individual contribution and knowledge by creating "novelties" that can translate into new products/process, business strategies, value and/or social value, norms and rules (*RQ2*, the innovative outcomes identified in Section 4.2.2). Therefore, by revealing the different enabling dimensions that foster the appearance of new value co-created outcomes in CTNA, innovation can be conceptualized as an emergent process.

As described in the findings, in the evolution from technological to practice-based innovation, all the different sub-systems identified in the cluster (supplying system, mobility system, institutional system and citizens) are involved gradually in the co-development of innovation by benefiting from the outcomes generated incrementally in the process. As the kind and the number of stakeholders involved increase (thus by transitioning from B2B to B2C, C2C, B2S/S2S and A4A), the degree of innovation inclusiveness and capacity broadens by determining the shift from technological/process innovation to business model, social and practice-based innovation.

As Figure 2 shows, the intersection of the two variables (innovation inclusiveness and capacity) can help disclosing the emergence of five shades of systems and systematic innovation, by demonstrating disruption and social changes can be pursued only through the constant improvement of the entire service system, of its people, interactions, technologies and value co-created innovative outcomes.

The different types of innovation identified in the diagram and detected from structural and systems activation of cluster's main enabling dimensions are introduced by five related propositions. These assumptions, listed in Table 3, are sequential and connected strictly with each other to highlight the incremental nature of systematic and systems innovation in which each different "degree-step" of innovation should be accomplished to move to the next "level".

As confirmed by the findings obtained, the cluster pursues innovation constantly (*systematic innovation*) by enveloping the different spheres (organizational, relational, human, cultural and social) of each embedded system (suppliers, sub-suppliers, private and non- profit organizations, academic institutions, citizens) in the general smart service system (*systems innovation*). Innovation and the proposition of new technologies, platforms, smart systems for monitoring and e-manufacturing (together with a total approach to data), seem to be the common thread of all the different shades of innovation, by revealing the high degree of "smartness" in CTNA service system.

6. Theoretical and managerial implications

The work reveals the emergence of different innovation patterns in Italian *National Cluster for Aerospace Technology* to conceptualize systems and systematic innovation, not conceived as the "simple" result of breakthrough but as the outcome of the continuous search for synergy and as the incremental building of social connections among actors.

Obtained from a complex mediation between induction and deduction, the diagram presented in Figure 2 classifies the various kinds of innovation that can emerge generally in smart service systems. The framework seeks to shed light on how the unique combination of specific resources, knowledge and skills between and among different actors across multiple contexts can produce gradually an innovation that is more and more inclusive and totalizing.

Then, from a theoretical standpoint, a research agenda is introduced that encourages future research to explore how innovation emergence can be fostered in smart service systems through the proposal of an original classification of:

- the key structural and systems enabling dimensions for innovation;
- the way in which these dimensions can reshape "traditional" processes of interactions and knowledge exchange.

The process-based view proposed allows at mediating constantly between the description of systems' elements (the "what" dimension) and the way in which the transition from structure to systems enables the creation of new technologies, resources, values and social rules across different contexts (the "how" dimension). In this way, a new conceptualization of systems and systematic innovation that overcomes the distinction between incremental and radical innovation is proposed (Wiersema, 2013; Akaka *et al.*, 2019).

Table 3 Five propositions to conceptualize the different shades of innovation

	Proposition
Technological innovation	*P1. The development of new materials, components, products and services leads to technological innovation*
↓ Process innovation	*P2. The introduction of new technologies and solutions enables the creation of new simplified and digitalized processes, which can enhance operations and information flows across supply chain*
↓ Business model and data-driven innovation	*P3. Enhanced and optimized flows of information and materials across the supply chain foster business-model innovation by promoting strategies diffusion from the establishment of value proposition and culture to resource selection and operation management thanks to a data-driven culture*
↓ Social and eco-sustainable innovation	*P4. The adoption of a new strategic orientation and (data) culture empowers human knowledge and entrepreneurial culture that lead to social innovation, which enhances well-being and introduces new environmental practices*
↓ Practice-based innovation	*P5. The introduction of technological, process, business model, social and environmental innovation is translated into the development of new (technical, cultural and social) practices that encourage the actors-driven diffusion of new rules for companies, institutions and citizens*

Source: Our elaboration

Therefore, the study can be considered as a further step in extending the body of knowledge on innovation emergence in smart service systems by categorizing the different mechanisms and practices fostering innovation (Abbate *et al.*, 2019), not only in B2B contexts but also in the extended networks of A4A relationships (Polese *et al.*, 2018). In this way, an original conceptualization of innovation in line with a broadened and systems view is introduced and dynamic capabilities are reframed as "activated" skills that can foster knowledge co-creation and innovation.

The classification of innovation hypothesized in this study can shed light on how given technologies can produce varied innovation outcomes according to the different kinds of stakeholders engaged.

The diagram proposed in Figure 2 can guide managers and policy-makers in the elaboration of effective strategies to use smart technologies and data analytics wisely and to exploit the opportunities offered by the multiple touchpoints and technological tools available in contemporary markets. Because of the association of different kinds of resources, technologies and co-creation practices with different innovation modalities and outcomes, managers can understand how to elaborate targeted strategies to enhance innovation, strengthen engagement and increase well-being.

The original conceptualization obtained from the analysis of CTNA can shed light on:

- how the implementation of given activities, resources and technological tools can produce different value co-creation practices;
- how the new knowledge exchanged and the new value co-created can foster the development of different innovation outcomes according to the different kinds of stakeholders engaged.

Thus, the relationship between technologies – and the efficient use of IT and ICTs platforms – and innovation has been clarified. Consequently, managers can collect some insights on the proper combination of technology and human interactions to manage strategically value co-creation that can allow, in turn, the harmonization of complex innovation processes. Some suggestions on "how" technology-enabled interactions can empower the dynamic integration of resources, through constant process of adaptation and reconfiguration, can contribute to identify the main drivers for continuous improvement (Russo-Spena and Mele, 2012; Medina-Borja, 2015).

Hence, practitioners can enhance their understanding of the contribution of a given tool or platform to co-creation, by differentiating the benefits that various participants can obtain (Abbate *et al.*, 2019).

In addition, the results can recommend some resource optimization strategies to produce different and new values by shaping actors' roles, aligning policymaking and decision-making to individual requirements and modelling strategically the structure of interactions. Roles alignment can be fostered through value co-development that increases the efficiency of technology-enabled value co-creation by allocating resources on joint activities that pursue common goals and by simplifying information exchange and ensuring role clarity.

Finally, the work can suggest how innovation outcomes (the new knowledge and standards) can be promoted and renewed constantly over time to pursue continuous improvement and to re-integrate the new resources obtained for the constant adaptation and proactive re-adaptation to complex contexts. In this way, the study advances a new conceptualization of innovation, intended both as a systems process (which embeds managerial, relational, culture and social dimensions) and a systematic process based on the establishment of a tension to innovation and of a transformative attitude.

7. Conclusions, limitations and future research

The different activities, resources, technologies (structural enabling dimensions) activated by the actors of CTNA, that play different roles, through skills and knowledge enhancement and data analysis strategies (systems enabling dimensions) are discussed above for each context of exchange (*RQ1*). Then, by observing the transition from structural to systems level and the key role performed by knowledge and value co-creation (determined by the enrichment of skills), different innovation modalities and outcomes can be detected (*RQ2*).

The findings of the work show how the adoption of an innovation mind-set and a learning orientation permit to pursue not only radical transformation and new solutions but also to attain durable and stable changes in business process, business models and in the strategies and relationships with users for ongoing change (Baccarani and Golinelli, 2014). The case of CTNA reveals how the emerging new elements co-developed (technologies, products/services, processes, strategies, social elements and rules), associated with different innovation modalities (introduced with five related propositions), can be renewed over time and re-institutionalized (Mele and Russo-Spena, 2019) to attain a state of constant "tension" to innovation.

Going beyond the activation of structural features, the activities fulfilled and the organizational climate spread in the Cluster confirm that an innovation orientation that envelops all the business functions, operations, strategies and actors' needs can create different shades of innovation that should be harmonized to pursue systematic innovation.

The systematic approach to innovation seems to emerge from the diffusion of an innovation culture enabling circular technology flows from universities to research organizations to firms. The analysis of the strategic collaboration with the accelerators (research centres, universities) highlights that the Cluster succeeds in bridging the gap between industrial players, education programs, research organizations, governmental agencies and local and national governments.

The common thread that connects efficiently and durably the actors is the constant organization and management of educational initiatives and projects (from consultancy and internships to high education programs). The learning mechanisms that are established through the dissemination of the competencies of employees, citizens, students and researchers, enable the renewal of innovation potential. The cluster invests in the education and constant training of the various actors involved and adopts *ad hoc* and diffused strategies that leverage on industrial, scientific, technical and academic skills to enhance competitiveness and well-being of each system in the network.

Systems and systematic innovation based on learning orientation enable the emergence of disruption in the cluster and the proactive identification of community's requirements to be predicted and satisfied. The real driving force for the improvement of CTNA smart service system is the establishment, internalization, and subsequent diffusion of an innovation culture to entrepreneurship that nurtures the virtuous cycle between investments in research and education. This culture fosters not only the development of new products or the improvement of existing ones but also changes the practices accomplished to use technology and to address users' rising needs. In this way, the synergistic incremental innovation and the constant renewal of value, based on the new culture generated and enriched gradually over time, allows the cluster at forecasting the needs, the expectations and the technological requirements of actors, over a long time horizon by attaining sustainable value co-creation and disruptive innovation.

The main limitation of the work is the poor number of interviewees included in the sample. Moreover, the application of case study methodology does not permit any generalization of results and prevents any extension of the interpretation of the findings to other contexts.

To address this issue, future research can start from the results proposed in the study to apply the classification of the different shades of innovation to other service systems or service contexts. The number of interviewees can be increased and comparative case studies (Yin, 1994) can be realized to assess whether the classification of innovation can be generalized to other clusters from different sectors (automotive, food, energy, etc.) in the same nation or to compare clusters from different nations. Mixed method can be used to combine quantitative and qualitative approaches: for instance, the existence of the main types of innovation conceptualized can be assessed through quantitative techniques, such as multiple regression or structural equation model, to explore the statistical relationships among constructs. In this way, not only generalizable results can be produced but also the relationships between the main drivers and outcomes of innovation hypothesized in this work can be tested and related to other key constructs of marketing such as users' behaviour, engagement or value co-creation.

References

Abbate, T., Codini, A. and Aquilani, B. (2019), "Knowledge co-creation in open innovation digital platforms: processes, tools and services", *Journal of Business & Industrial Marketing*, Vol. 34 No. 7, pp. 1434-1447.

Addeo, F. and Montesperelli, P. (2007), *Esperienze di Analisi di Interviste Non Direttive*, Aracne, Roma.

Akaka, M.A., Koskela-Huotari, K. and Vargo, S.L. (2019), "Further advancing service science with service-dominant logic: Service ecosystems, institutions, and their implications for innovation", in Maglio, P.P., Kieliszewski, C.A., Spohrer, J.C., Lyons, K., Patricio, L. andSawatani, Y. (Ed.), *Handbook of Service Science*, Vol. 2, Springer Nature Switzerland AG, Cham, pp. 641-659.

Alexander, M. and Jaakkola, E. (2011), "Exploring value co-creation within networks: actor-to-actor service provision within a public transport service system", paper presented at the Industrial Marketing and Purchasing Conference, 31 August- 3 September, Glasgow, available at: https://strathprints.strath.ac.uk/33796/1/237.pdf

Baccarani, C. (2011), "Sui sentieri della creatività", *Sinergie Italian Journal of Management*, Vol. 64-65 No. 4, pp. 347-360.

Baccarani, C. and Golinelli, G.M. (2014), "Le parole dell'innovazione", *Sinergie Italian Journal of Management*, Vol. 94, pp. 9-14.

Badinelli, R.D. and Sarno, D. (2016), "Integrating the internet of things and big data analytics into decision support models for healthcare management", *Proceedings of the 5th Naples Forum on Service. Service-Dominant Logic, Network & Systems Theory and Service Science: Integrating three perspectives for a new service agenda Academic Press. doi: 0.4258/hir*, Vol. 3.

Barile, S. (2006), *L'impresa Come Sistema: contributi Sull'Approccio Sistemico Vitale (ASV)*, Giappichelli, Torino.

Barile, S. and Polese, F. (2010), "Smart service systems and viable service systems: applying systems theory to service science", *Service Science*, Vol. 2 Nos 1/2, pp. 21-40.

Barile, S. and Saviano, M. (2006), "Le basi del pensiero sistemico: la dicotomia struttura-sistema", in Barile, S. (Ed.), *L'impresa Come Sistema. contributi Sull'Approccio Sistemico Vitale (ASV)*, Giappichelli, Torino, pp. 63-81.

Barrett, M., Davidson, E., Prabhu, J. and Vargo, S.L. (2015), "Service innovation in the digital age: key contributions and future directions", *MIS Quarterly*, Vol. 39 No. 1, pp. 135-154.

Blomkvist, J., Holmlid, S. and Segelström, F. (2011), "Service design research: yesterday, today and tomorrow", in Stickdorn, M. and Schneider, J. (Ed.), *This is Service Design Thinking*, BIS Publishers, Amsterdam, pp. 308-315.

Breidbach, C.F. and Brodie, R.J. (2017), "Engagement platforms in the sharing economy: conceptual foundations and research directions", *Journal of Service Theory and Practice*, Vol. 27 No. 4, pp. 761-777.

Breidbach, C.F. and Maglio, P.P. (2016), "Technology-enabled value co-creation: an empirical analysis of actors, resources, and practices", *Industrial Marketing Management*, Vol. 56, pp. 73-85.

Brewer, J.D. and Hunter, A. (2006), *Foundations of Multimethod Research: Synthesizing Styles*, Sage Publications, Thousand Oaks, CA.

Carrubbo, L., Bruni, R., Cavacece, Y. and Moretta Tartaglione, A. (2015), "Service system platforms to improve value co-creation: insights for translational medicine", in Gummesson, E., Mele, C. and Polese, F. (Ed.), *Service-Dominant Logic, Network and Systems Theory and Service Science: Integrating Three Perspectives for a New Service Agenda*, Giannini, Napoli, pp. 1-18.

Charmaz, K. (2000), "Grounded theory: objectivist and constructivist methods", in Denzin, N. K. and Lincoln, Y.S. (Ed.), *Handbook of Qualitative Research*, Sage Publications, Thousand Oaks, CA, pp. 509-535.

Colquitt, J.A. and Zapata-Phelan, C.P. (2007), "Trends in theory building and theory testing: a five-decade study of the academy of", *Academy of Management Journal*", Vol. 50 No. 6, pp. 1281-1303.

Davis, M.M., Spohrer, J.C. and Maglio, P.P. (2011), "How technology is changing the design and delivery of services", *Operations Management Research*, Vol. 4 Nos 1/2, pp. 1-5.

Dougherty, D. (2004), "Organizing practices in services: capturing practice-based knowledge for innovation", *Strategic Organization*, Vol. 2 No. 1, pp. 35-64.

Dubois, A. and Gadde, L.E. (2014), "Systematic combining: a decade later", *Journal of Business Research*, Vol. 67 No. 6, pp. 1277-1284.

Edvardsson, B., Skålén, P. and Tronvoll, B. (2015), "Service systems as a foundation for resource integration and value co-creation", *Review of Marketing Research*, Vol. 9 No. 1, pp. 79-126.

Eisenhardt, K.M. (1989), "Building theories from case study research", *Academy of Management Review*, Vol. 14 No. 4, pp. 532-550.

Frost, R. and Lyons, K. (2017), "Service systems analysis methods and components: a systematic literature review", *Service Science*, Vol. 9 No. 3, pp. 181-262.

Gallouj, F. (2002), "Knowledge-intensive business services: processing knowledge and producing innovation", in Gadrey, J. and Gallouj, F. (Ed.), *Productivity, Innovation and Knowledge in Services: New Socio-Economic Approaches*, Edward Elgar, Cheltenham, pp. 256-284.

Glaser, B. (2002), "Constructivist grounded theory?", *Forum: Qualitative Social Research*, Vol. 3 No. 3, pp. 1-14.

Glaser, B. and Strauss, A. (1967), *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine, Chicago, IL.

Gummesson, E. (2017), *Case Theory in Business and Management: reinventing Case Study Research*, Sage Publications, Thousand Oaks, CA.

Gummesson, E. and Polese, F. (2009), "B2B is not an island!", *Journal of Business & Industrial Marketing*, Vol. 24 Nos 5/6, pp. 337-350.

Karlsson, C., Johansson, B. and Stough, R.R. (2005), "Industrial clusters and inter-firm networks: an introduction", in Karlsson, C., Johansson, B., Stough, R.R. (Ed.), *Industrial Clusters and Inter-Firm Networks*, Edward Elgar, Cheltenham, pp. 1-25.

Kieliszewski, C.A. and Anderson, L.C. (2019), "People and social interaction: drivers of service innovation", in Maglio, P.P., Kieliszewski, C.A., Spohrer, J.C., Lyons, K., Patricio, L., Sawatani, Y. (Eds), *Handbook of Service Science*, Vol. 2, Springer Nature Switzerland AG, Cham, pp. 307-325.

Koskela-Huotari, K., Edvardsson, B., Jonas, J.M., Sörhammar, D. and Witell, L. (2016), "Innovation in service ecosystems: breaking, making, and maintaining institutionalized rules of resource integration", *Journal of Business Research*, Vol. 69 No. 8, pp. 2964-2971.

Lim, C. and Maglio, P.P. (2019), "Clarifying the concept of smart service system", in Maglio, P.P., Kieliszewski, C.A., Spohrer, J.C., Lyons, K., Patricio, L., Sawatani, Y. (Ed.), *Handbook of Service Science*, Vol. 2, Springer Nature Switzerland AG, Cham, pp. 349-375.

Lim, C., Maglio, P.P., Kim, K., Kim, M. and Kim, K. (2016), "Toward smarter service systems through service-oriented data analytics", *Proceedings of 2016 I.E. E.E. 14th International Conference on Industrial Informatics (INDIN) in Poitiers, France, 19-21 July 2016, Institute of Electrical and Electronics Engineers (IEEE), Piscataway, NJ*, pp. 936-941.

Lusch, R.F. and Nambisan, S. (2015), "Service innovation: a service-dominant logic perspective", *MIS Quarterly*, Vol. 39 No. 1, pp. 155-175.

Maglio, P.P. and Spohrer, J. (2008), "Fundamentals of service science", *Journal of the Academy of Marketing Science*, Vol. 36 No. 1, pp. 18-20.

Maglio, P.P., Kwan, S.K. and Spohrer, J. (2015), "Commentary: toward a research agenda for human-centered service system innovation", *Service Science*, Vol. 7 No. 1, pp. 1-10.

Maglio, P.P., Srinivasan, S., Kreulen, J.T. and Spohrer, J. (2006), "Service systems, service scientists, SSME, and innovation", *Communications of the ACM*, Vol. 49 No. 7, pp. 81-85.

Martín-de Castro, G., López-Sáez, P., Delgado-Verde, M., Quintane, E., Mitch Casselman, R., Sebastian Reiche, B. and Nylund, P. (2011), "Innovation as a knowledge-based outcome", *Journal of Knowledge Management*, Vol. 15 No. 6, pp. 928-947.

Medina-Borja, A. (2015), "Smart things as service providers: a call for convergence of disciplines to build a research agenda for the service systems of the future", *Service Science*, Vol. 7 No. 1, pp. 2-5.

Mele, C. and Russo-Spena, T. (2019), "Innovation in sociomaterial practices: the case of IoE in the healthcare ecosystem", in Maglio, P.P., Kieliszewski, C.A., Spohrer, J. C., Lyons, K., Patricio, L. and Sawatani, Y. (Ed.), *Handbook* *of Service Science*, Vol. 2, Springer Nature Switzerland AG, Cham, pp. 517-544.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative Data Analysis*, Sage Publications, Thousand Oaks, CA.

Mills, J., Bonner, A. and Francis, K. (2006), "Adopting a constructivist approach to grounded theory: implications for research design", *International Journal of Nursing Practice*, Vol. 12 No. 1, pp. 8-13.

OECD (2005), "Oslo manual guidelines for collecting and interpreting innovation data", available at: https://ec.europa.eu/eurostat/documents/3859598/5889925/OSLO-EN.PDF/60a5a2f5-577a4091-9e09-9fa9e741dcf1

Peredo, A.M. and Chrisman, J. (2006), "Toward a theory of community-based enterprise", *Academy of Management Review*, Vol. 31 No. 2, pp. 309-328.

Piciocchi, P., Bassano, C., Pietronudo, M.C. and Spohrer, J.C. (2019), "Digital workers in service systems: challenges and opportunities", in Maglio, P.P., Kieliszewski, C.A., Spohrer, J.C., Lyons, K., Patricio, L. andSawatani, Y. (Eds), *Handbook of Service Science, Volume II*, Springer Nature Switzerland AG, Cham, pp. 409-432.

Polese, F. (2009), "The influence of networking culture and social relationships on value creation", *Quaderni di Sinergie: Firms' Management: Processes, Networks and Value*, Vol. 16 No. 80, pp. 193-215.

Polese, F., Sarno, D., Troisi, O. and Grimaldi, M. (2018), "From B2B to A4A: an integrated framework for viable value Co-Creation", *Mercati & Competitività*, Vol. 3, pp. 135-162.

Ramaswamy, V. and Gouillart, F. (2010), "Building the co-creative enterprise", *Harvard Business Review*, Vol. 88 No. 10, pp. 100-109.

Russo-Spena, T. and Mele, C. (2012), "Five Co-s" in innovating: a practice-based view", *Journal of Service Management*, Vol. 23 No. 4, pp. 527-553.

Sangiorgi, D., Lima, F., Patrício, L., Joly, M.P. and Favini, C. (2019) "A human-centred, multidisciplinary, and transformative approach to service science: a service design perspective", in Maglio, P.P., Kieliszewski, C.A., Spohrer, J.C., Lyons, K., Patricio, L. and Sawatani, Y. (Ed.), *Handbook of Service Science*, Vol. 2, Springer Nature Switzerland AG, Cham, pp. 147-181.

Siltaloppi, J., Koskela-Huotari, K. and Vargo, S.L. (2016), "Institutional complexity as a driver for innovation in service ecosystems", *Service Science*, Vol. 8 No. 3, pp. 333-343.

Snyder, H., Witell, L., Gustafsson, A., Fombelle, P. and Kristensson, P. (2016), "Identifying categories of service innovation: a review and synthesis of the literature", *Journal of Business Research*, Vol. 69 No. 7, pp. 2401-2408.

Spohrer, J.C. and Demirkan, H. (2015), "Introduction to the smart service systems: analytics, cognition, and innovation minitrack", *Proceedings of the 48th Annual HI International Conference on System Science (HICSS), January 5-8 2015, Kauai, HI, USA, IEEE Computer Society Conference Publishing Services (CPS), Washington, DC*, pp. 1442-1442.

Spohrer, J., Maglio, P.P., Bailey, J. and Gruhl, D. (2007), "Steps toward a science of service systems", *Computer*, Vol. 40 No. 1, pp. 71-77.

Spohrer, J., Vargo, S.L., Caswell, N. and Maglio, P.P. (2008), "The service system is the basic abstraction of service science", *Proceedings of the 41st Annual HI International Conference on System Sciences (HICSS), January 7-10 2018, Waikoloa, Big Island, HI, USA, IEEE Computer Society Conference Publishing Services (CPS), Washington, DC*, p. 104.

Storbacka, K. and Nenonen, S. (2011), "Markets as configurations", *European Journal of Marketing*, Vol. 45 Nos 1/2, pp. 241-258.

Strauss, A. and Corbin, J. (1994), "Grounded theory methodology: an overview", in Denzin, N.K. and Lincoln, Y.S. (Ed.), *Handbook of Qualitative Research*, Sage Publications, Thousand Oaks, CA, pp. 273-285.

Strauss, A. and Corbin, J. (1998), *Basics of Qualitative Research Techniques*, Sage Publications, Thousand Oaks, CA.

Ugolini, M. (1999), "Tecnologie dell'informazione e fiducia: la nuova sfida per l'impresa", sinergie", *Italian Journal of Management*, Vol. 50, pp. 63-89.

Ugolini, M. (2004), *Un Approccio di Service Management per la Gestione Del Reparto Ospedaliero*, Giuffrè Milan.

Vargo, S.L., Lusch, R.F. (2011), "It's all B2B… and beyond: toward a systems perspective of the market", *Industrial Marketing Management*, Vol. 40 No. 2, pp. 181-187.

Vargo, S.L. and Lusch, R.F. (2016), "Institutions and axioms: an extension and update of service-dominant logic", *Journal of the Academy of Marketing Science*, Vol. 44 No. 1, pp. 5-23.

Vargo, S.L., Wieland, H. and Akaka, M.A. (2015), "Innovation through institutionalization: a service ecosystems perspective", *Industrial Marketing Management*, Vol. 44, pp. 63-72.

Von Bertalanffy, L. (1968), *General System Theory: Foundations, Development, Applications*, George Braziller, New York, NY.

Wiersema, F. (2013), "The B2B agenda: the current state of B2B marketing and a look ahead", *Industrial Marketing Management*, Vol. 42 No. 4, pp. 470-488.

Yin, R.K. (1994), *Case Study Research: Design and Methods*, Sage Publications, Thousand Oaks, CA.

Yin, R.K. (2011), *Applications of Case Study Research*, Sage Publications, Thousand Oaks, CA.

Yin, R.K. (2013), "Validity and generalization in future case study evaluations", *Evaluation*, Vol. 19 No. 3, pp. 321-332.

Further reading

Chandler, J.D., Danatzis, I., Wernicke, C., Akaka, M.A. and Reynolds, D. (2019), "How does innovation emerge in a service ecosystem?", *Journal of Service Research*, Vol. 22 No. 1, pp. 75-89.

Ostrom, A.L., Bitner, M.J., Brown, S.W., Burkhard, K.A., Goul, M., Smith-Daniels, V. and Rabinovich, E. (2010), "Moving forward and making a difference: research priorities for the science of service", *Journal of Service Research*, Vol. 13 No. 1, pp. 4-36.

Polese, F., Pels, J., Tronvoll, B., Bruni, R. and Carrubbo, L. (2017), "A4A relationships", *Journal of Service Theory and Practice*, Vol. 27 No. 5, pp. 1040-1056.

Spohrer, J., Piciocchi, P. and Bassano, C. (2012), "Three frameworks for service research: exploring multilevel governance in nested, networked systems", *Service Science*, Vol. 4 No. 2, pp. 147-160.

Appendix

Interview Sketch 1

RQ1- structural and systems analysis
Structural

- Which are the main *actors* in the cluster connected with you?
- Which goals do you pursue through the establishment of relationships in the cluster?
- Which *activities* do you perform for the cluster?
- Which are the key *technology tools* for the interactions with the other members of the cluster?
- Which are the key *technology tools* for the fulfilment of activities' and projects' goals?
- Which are the main *resources* do you exchange with the other actors?
- Which kind of support and benefits do you offer? Which kind of support and benefits do you receive?

Systems

- Do you acquire new *competencies* through the collaborations in the cluster?
- Do you share your *knowledge* with other members of the cluster?
- Do you organize training activities for the other members of the cluster?
- Do you share your strategic guidelines, your work and your employees with other members of the cluster?
- Do you share your technological instruments (information technologies) with other members in the cluster?
- Do you support the other members of the cluster in *data analysis*?
- Do you share the results of *data analysis* with other members in the cluster?
- How frequent is your communication with the other members in the cluster?
- Do you share your ideas with the other members in the cluster?
- Do you manage relationships between two or more different organizations in the cluster (that do not have direct contact with each others)?

RQ2- innovation emergence

- Did you introduce new *products/services/technologies* by means of the collaboration in the cluster and/or after the realization of joint activities? How many new products/services/technologies have been realized in the last three years?
- Did you increase your *knowledge* through the collaboration in the cluster and/or after the realization of joint activities?
- Which new competencies did you acquire in the last three years?
- Do you think that collaboration in the cluster improved *Human* resources management and valorization?
- Do you think that the realization of joint projects increased the competencies of employees/staff/citizens? Do you think that the realization of joint projects increased the satisfaction of employees and/or the quality of life of citizens?
- Do you think that the realization of joint activities provided *society* with some benefits?
- Which social outcomes did the cluster obtained? Which benefits for the community?
- Do you think that joint activities in the cluster contributed to enhance the sense of belonging to community?

Interview Sketch 2

RQ1- structural and systems analysis
Structural

- Which are the most relevant and strategic *actors* in the realization of joint projects?
- Which kind of goals did you pursue in the cluster in the long run? Which kind of values did you generate after the joint realization of *activities* and projects?
- Which are the main social and economic effects of the *activities* realized?
- Are the *technology tools* used in the cluster connected among each other?
- Do you adopt different *technology tools* for the different activities?
- How did the *technology tools* used improve your communication with the other actors in the cluster?
- Do you plan which kind of *resources* to exchange with the other actors?
- Do you share your strategic guidelines and business philosophy with the other members of the cluster?
- Do you share your expertise with the other members of the cluster?
- Which are the most relevant *resources* for your survival that you exchange with other members? And for the survival of relationships?

Systems

- Do you think that collaborations in the cluster provide you with relevant *knowledge*?
- Do you think that your know-how is enriched after the realization of joint projects?
- Do you establish stable relationships with schools, universities and the academic world?
- Do you think that the degree of *knowledge* in the cluster improved after the realization of joint projects?
- Do you and/or your employees/staff acquire some knowledge on the use of technology platforms? Do you and/or your employees/staff acquire some knowledge on *data analysis* and interpretation?
- Do you collect data permanently? Did you hire some new professional figures for data analysis?
- Do you think that your *role* in the cluster is relevant for the realization of activities and the fulfilment of goals?

- Do you think that your *role* is relevant for the development of innovation in the cluster?

RQ2- innovation emergence

- Which are the new *materials*, *components*, *products*, ITs/ICTs services introduced in the past three years?
- Did you use the new technologies introduced to digitalize your business *processes*?
- How did you use technologies to improve *supply chain*? How did you use technologies to improve information flows between the different departments of your organizations/between the organizations in the cluster?
- Do you think that process digitalization improved relationships management in the cluster?
- Do you think that improved relationships helped the strengthening of cluster's *strategies*?
- Do you think that improved relationships contributed to create a cohesive and shared culture in the cluster?
- Do you think that clusters' orientation is changed in the last three years?
- Do you think that the actors in the cluster improved the effectiveness of their *data analysis* and management?
- Do you think that the realization of joint activities improved the *social* inclusion of citizens?
- Do you think that public actors contributed to the realization of innovative solutions in the cluster?
- Do you think that the involvement of universities and schools contributed to the realization of innovative solutions in the cluster?
- According to you, did the cluster create some new attitude in aerospace sector?
- According to you, did the cluster promote digital culture?
- According to you, did the joint realization of activities introduce some changes in Aerospace and mobility?
- Do you think that the collaboration increased *community* empowerment?
- Do you think that the cluster introduced new *rules* and *habits* in the way citizens live territories?

Corresponding author

Orlando Troisi can be contacted at: otroisi@unisa.it