Digital transformation challenges: strategies emerging from a multi-stakeholder approach

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Abstract

Purpose – This paper proposes adequate strategies that companies, public administrators and organisations in the education industry can undertake to successfully face the challenges of digital transformation in a regional innovation system. This research considers stakeholders that operate in the Tyrol–Veneto macroregion (the Tyrol, South Tyrol and Veneto areas), a significant case of moderately innovative European macroregion.

Design/methodology/approach – This study undertakes explorative research based on a qualitative method. It adopts a place-based multi-stakeholder approach to emphasise the role of three categories of stakeholders (companies, educational system and regional governments) in facing digital changes. More precisely, interviews with 60 stakeholders from the Tyrol–Veneto macroregion were conducted and examined via both text mining analysis and content analysis. First, correspondence factor analysis was performed using IRaMuTeQ software to identify homogeneous subsets of concepts (pillars–i.e., macroareas of strategic actions). Second, two coding phases were implemented using NVivo software to detect strategic fields of action and specific strategic actions undertaken to address the challenges of digital transformation.

Findings – The results highlight that digital transformation is a pervasive challenge of regional innovative system that requires a multifaceted set of strategic actions falling into three main pillars. The first pillar, named "culture and skills", includes three strategic fields of action as follows: digital education, talents and digital culture. The second pillar, named "infrastructures and technologies", points out the need of information, interaction and artificial intelligence as key strategic fields of action. The third pillar, named "ecosystems", highlights the importance of investing in medium- to long-term visions, partnerships and life quality. In brief, this study shows that standalone interventions are insufficient to tackle digital transformation from a systemic perspective. Moreover, this study outlines the potential contribution of each category of stakeholder to foster the digitalisation of the Tyrol–Veneto macroregion.

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Practical implications – This study highlights the importance of developing digital culture and skills before investing in digital infrastructure and technology in a moderately innovative macroregion. Companies should alter their vision before reconfiguring their business models, invest in smart working and establish contacts with start-ups. In addition, this study recommends that public administration should mainly invest in digital education and partnerships, while, in terms of education and training organisations, it suggests providing digital skills to several cohorts of both students and workers. Policy implications call for the creation of new occasions of cooperation among stakeholders by fostering "table talks" as strategic and policy actions and by making more financial resources available to encourage the digital transformation processes.

Originality/value – The results of this study may be adapted to the characteristics of other regional innovative systems and used as a reference point in terms of the improvement of business, market and local development.

Keywords Place-based strategies, Regional innovation system, Culture and skills, Infrastructure and services, Technology, Digital ecosystems

Paper type Research paper

1. Introduction

Although digitalisation, the digital revolution and digital transformation have undoubtedly become a trending topic in recent years (e.g. Alcacer, 2016; Sommer *et al.*, 2017; Tekic and Koroteev, 2019), why speak of digitalisation just now? After all, information technology (IT) and IT research have been around for over 50 years now. Essentially, electronic data processing, personal computing, communication technologies, the Internet and social media are some of the most notable events marking the history of IT, and all this began in the mid-20th century. Recent advances such as big data, artificial intelligence (AI) and biocomputing legitimise buzzwords like digitalisation and digital transformation by heralding the advent of a new era in IT (Downes and Nunes, 2013). In other terms, the digital transformation is everywhere; no business industry or organization is immune to its effects (Hess *et al.*, 2016). Information, knowledge and processing capacity are now permanent and ubiquitous, and the growing connections between people, objects, devices and systems are modifying the conditions under which individuals, businesses and societies live and operate.

In addition, why it is important to discuss digitalisation and digital transformation? Because digitalisation deals with information processing and everything can be turned into information, digitalisation affects every human activity. It is pervasive, involving nearly every domain, and is profoundly transforming the economy and contemporary society (Curran, 2018). On the one hand, more and more companies are investing heavily in new digital technologies, experimenting with new possibilities and changing their business models (e.g. Farrington and Alizadeh, 2017; Nambisan *et al.*, 2017; Frishammar *et al.*, 2018). On the other hand, digitalisation permeates the daily lives of individuals, both privately and professionally: people learn via social media, interact with intelligent machinery in the workplace, transmit and receive data via tablets or smartphones, as well as benefit from integrated, shared and updated real-time mobility systems.

Given the wide-ranging impact of digitalisation, it is essential to understand, reflect on and realise what is taking place. It is important that stakeholders face digital changes in a systematic manner (Cooke, 2001; Coenen *et al.*, 2017). In this regard, more and more regions and macro-regions have adopted specific actions for "local intelligent digitalisation" through multidimensional interventions that involve numerous stakeholders and integrate multiple scales of intervention. Some of the existing studies (e.g. Bahrami and Stuart, 2011; McAfee *et al.*, 2014; Duvivier and Polèse, 2018) look at clusters or regions or neighbourhoods that are considered as leaders in digitalisation (e.g. Silicon Valley in San Francisco, TechCity in the United Kingdom, Silicon Alley in Manhattan and Silicon Roundabout in London), tailoring the challenges of digitalisation to their characteristics and often using them as a benchmark. However, it is possible to identify alternative approaches to digitalisation. Some systems can specialise in the development of future general purpose technologies for the fourth industrial

revolution, while others will invest in the co-invention of applications to address the particular problems of quality and productivity in one or a few industries in their economies. In this context, each region faces specific challenges (e.g. Evangelista *et al.*, 2018). This entails the need to elaborate suitable place-based strategies to tackle the idiosyncratic challenges engendered by digitalisation (e.g. Coenen *et al.*, 2017) according to the relevant "regional knowledge domain" (Cooke, 2001). Given that the pace of digital adoption differs significantly across European regions (European Commission, 2018), the case of moderately innovative regions in Europe deserves specific attention for the following two reasons (e.g. Schmidt *et al.*, 2018): 1) their role in contributing to diversifying "the industrial knowledge commons" of the continent and 2) their role in generating a basis for assessing the resources that may be deployed in the transition and evolution of new possible digital-based specialisation.

This paper aims to fill this research gap by answering the following research question: what should stakeholders do to successfully face the challenges of digital transformation in a regional innovation system? To address this question, this paper proposes adequate strategies in terms of macro-areas of action (i.e. pillars), fields of action and specific interventions that different categories of stakeholders (namely, companies, public administrators and education and research institutions) have recently undertaken, are undertaking or are willing to undertake to face the transformations induced by digitalisation in a regional innovation system. In this regard, this research, which is explorative in nature, considers stakeholders operating in the Tyrol–Veneto macro-region (the Tyrol, South Tyrol and Veneto areas) – a cross-border, moderately innovative European macro-region straddling Italy and Austria. The results of this study may be adapted to the characteristics of other regional innovative systems and used as a reference point for improving business, market and local development.

The structure of this paper is as follows. After a review of the literature on digitalisation, regional innovation systems and business strategies for digitalisation, the methodology is described. Subsequently, the results are presented and discussed, and the conceptual and practical implications are proposed. The paper closes with concluding remarks.

2. Literature review

2.1 Main topics about digitalisation

Over recent decades, the scientific literature has paid increasing attention to digitalisation as a core engine of the fourth industrial revolution (Alcacer, 2016; Sommer *et al.*, 2017) and its effects on organisations, economies and societies. The distribution of publications over time clearly shows a boost in the scientific community's interest in digitalisation and digital transformation. The main research streams of digitalisation literature are focused on the following topics: (1) digitalisation as a bundle of changes, (2) key technologies of digitalisation, (3) challenges of digitalisation and (4) enabling factors.

First, several papers view "digitalisation as a bundle of social, economic and cultural changes" triggered by the increasing use of digital technologies (e.g. Majchrzak *et al.*, 2016; Parviainen *et al.*, 2017), or as a set of transformations of the techno-economic environment and socio-institutional operations engendered by digital communications and applications (Katz and Koutroumpis, 2013). From a more business-oriented perspective, digitalisation is often viewed as a source of disruptions triggering strategic responses (Vial, 2019), and as a driver of product and marketing innovation (Stone *et al.*, 2017).

A second topical issue is related to the "key technologies of digitalisation". Different technologies can be used to create digital variants of products or services to enable communication and interaction between machines, people and objects. Some of these, however, show comparable characteristics and can be aggregated into homogeneous categories, such as the six ones identified by the SMACIT acronym (social, mobile, analytics, cloud and Internet of things) proposed by Sebastian *et al.* (2017). Other useful macro-categories include platforms (Tiwana *et al.*, 2010), advanced and additive manufacturing

technologies (Savastano *et al.*, 2019) and algorithmic decision-making (Newell and Marabelli, 2015). This last category, based on artificial intelligence, is more and more crucial as it will probably become a general-purpose technology and thus a major driver of long-term technological progress in the next future (Cockburn, 2018; Phan *et al.*, 2017).

A third thematic area deals with the main "challenges of digitalisation". Although the nature of these challenges is multifaceted, it is possible to divide them into three broad categories: (1) market challenges, (2) organisational challenges and (3) economic and societal challenges. More precisely, market challenges include the transformation of specific businesses models (Matzler *et al.*, 2018), such as the evolution of servitisation (Coreynen *et al.*, 2017; Paiola, 2018), the impact of digitalisation on supply chains (Caputo *et al.*, 2018) and producer–customer relationships (Fremont *et al.*, 2018) and the potential relocation of firms' operations in high labour cost countries (reshoring) made possible by the increased degree of automation of production processes (Wiesmann *et al.*, 2017).

Organisational challenges mainly deal with knowledge management, grounded in the increasing accessibility of document repositories and information-based platforms (Yoo *et al.*, 2012). Economic challenges basically refer to the impact of new digital paradigms on labour demand (Kaivo-Oja *et al.*, 2017; Dengler and Matthes, 2018), while societal challenges deal with the impact of environmental sustainability, notably resource efficiency (Beier *et al.*, 2017) and energy consumption (Tiefenbeck *et al.*, 2018).

A fourth thematic area deals with the "enabling factors" (enablers) that organisations and the surrounding system should develop to take advantage of new digital paradigms (e.g. Evangelista *et al.*, 2018). One group of enablers refers to the internal re-organisation of the firm, such as the need to develop new bundles of skills (Butschan *et al.*, 2019) to implement cultural change aimed at creating new models of leadership (Heavin and Power, 2018), activating appropriate human resource management practices (Carlsson, 2018) and improving change management capabilities (Grover and Kohli, 2013). A second group of enablers is external and deals with collaborative partnerships. Their common point is that digitalisation has transformed the supply chain such that value creation is concentrated in firm boundaries and inter-firm relationships (Sommer *et al.*, 2017; Farrington and Alizadeh, 2017), while digital transformation often requires the achievement of open innovation dynamics (Frishammar *et al.*, 2018).

In brief, academic literature is dominantly focused on specific aspects such as nature, key technologies, challenges and drivers of digital transformation. Further interest is recalling the digital transformation strategy topic (e.g. Kane *et al.*, 2015; Matt *et al.*, 2015). However, this research topic is essentially related to business world, named digital business strategy (Bharadwaj *et al.*, 2013). Given that digital business strategy alone is not enough to help managers navigate through the transformation process, some scholars suggest to provide a big picture (Hess *et al.*, 2016). For example, Tekic and Koroteev (2019) identify distinctive digital transformation strategies in terms of two critical dimensions: usage of digital technologies and readiness of a business model for digital operation. They propose four generic digital transformation strategies that essentially differ in the primary motivation and target of transformation: leadership style, importance of skills like creativity and entrepreneurial spirit among employees, risks and challenges faced in the process, consequences of potential failure and available tactics for improvement.

2.2 Regional innovation systems and business strategies for digitalisation

Moving to a systemic perspective, a specific research avenue deals with the environmental conditions faced by organisations in developing their digital strategies. The scope of this challenge is essentially threefold. First, a systemic approach stresses the need for a significant transformation of the company's ecosystems (suppliers, partners and customers) "to a state where value is co-created . . . through the optimization of resource usage, and the effective operation and leveraging of digital technologies" (Parida *et al.*, 2019, p. 13). A typical

case is the shift from product platforms to platform ecosystems based on network interactions, which are viewed as the backbone of successful servitisation strategies in the digital age (Cenamor *et al.*, 2017). Second, at an industrial level, the integration of digital and non-digital assets in innovative ways and the emergence of new work structures has allowed for a substantial redefinition of sectoral boundaries (Nambisan *et al.*, 2019). Third, the digital transformation is shaped by the interaction between technologies and the people who use these technologies (Dini *et al.*, 2011), as well as by local innovation policies (Asheim *et al.*, 2019), while the dynamic and continuous changes resulting from these components form the behaviour of the relevant digital ecosystems (Sussan and Acs, 2017).

Accordingly, organisations typically face specific environmental conditions in developing their digital strategies, provided that each entrepreneurial system or regional innovation system has an idiosyncratic "knowledge domain" (e.g. Cooke, 2001; Coenen *et al.*, 2017), while the digital transformation of innovation and entrepreneurship has "the potential to inform policy making entities and other stakeholders" (Nambisan *et al.*, 2019, p. 1). Thus, to understand modern entrepreneurial ecosystems and regional innovation systems, it is important to assess how digitalisation shapes value creation, delivery and capture in such contexts (Nambisan, *et al.*, 2017; Yoo *et al.*, 2012), while all relevant stakeholders need to undertake multi-level place-based actions to assure the success of digital transformation strategies (Schmidt *et al.*, 2018). These actions usually include increasing use of digital platforms (Kenney and Zysman, 2016) and "open" approaches to innovation (Chesbrough, 2006), based on the collaboration between a broader range of actors than in the past (Tödtling and Trippl, 2018). However, under this view, such actions cannot be adopted regardless of the nature of the organisation, market segment or geographical area. It is also crucial to analyse how digital transformation unfolds in different types of ecosystems and which tools and initiatives fit best to each specific spatial context. Despite these contributions, there has been limited research on systemic issues and particularly how organisations (not only companies) and policy makers can consider the heterogeneity of initial conditions and target different groups and contexts to develop their digital strategies. Thus, it would be valuable to examine the specificities of different types of regional innovation systems to elaborate suitable place-based strategies to tackle the idiosyncratic challenges engendered by digitalisation. Indeed, the literature has defined the digital ecosystem as "a self-organizing, scalable and sustainable system composed of heterogeneous digital entities and their interrelations" (Li *et al.*, 2012, p. 119), yet it has not provided a contingent theory that differentiates them according to their features. In view of this gap and assuming that digitalisation facilitates the horizontal knowledge sharing and interactions that reinforce the relevant ecosystem (Thompson *et al.*, 2018; Goswami *et al.*, 2018) the heterogeneity of European regions requires a place-based approach to identify the necessary strategies to face the challenges of digital transformation according to the particular region. A research agenda examining patterns of digitalisation across increasingly complex yet still heterogeneous ecosystems would constitute a significant advancement of the scientific debate and would be helpful to derive suitable implications for policy makers needing to consider the heterogeneity of initial conditions and target different groups and contexts with dedicated interventions.

Given the limited research published on regional innovation system and business strategy about digitalisation, this study aims to identify the strategies that stakeholders – especially companies, public administrators and organisations in the education industry – undertake to successfully face the challenges of digital transformation in a regional innovation system, such as the Tyrol–Veneto macro-region.

3. Research method

3.1 Research design

As highlighted in the literature review, several studies have emphasised the influence of various stakeholders in facing digital changes (Cooke, 2001; Bahrami and Stuart, 2011;

McAfee *et al.*, 2014; Coenen *et al.*, 2017; Duvivier and Polèse, 2018), such as companies, organisations of public administration and organisations from the education industry. Accordingly, the identification of adequate strategies to successfully face the challenges of digital transformation in relation to the macro-region is highly dependent on the use of a multi-stakeholder approach. Thus, this study adopted a multi-stakeholder approach for the two following reasons: (1) all stakeholders involved or interested in the macro-region can be given the opportunity to be considered into the analysis and (2) this approach helps map interrelations and interdependences among the various stakeholders. This research is based on interviews undertaken with 60 stakeholders from the Tyrol–Veneto cross-border macro-region. The use of this method enables a holistic understanding of respondents' experiences that could not be achieved otherwise (Kulik *et al.*, 2012).

3.2 The context of the study: the Tyrol–Veneto macro-region

The Tyrol–Veneto cross-border macro-region includes the Tyrol region in Austria – South Tyrol, particularly the autonomous province of Bolzano and the Veneto region in Italy. It presents a mature and relatively homogeneous economic system with an above EU average GDP per capita, but growth rates are below average. In terms of economic profile, this macro-region shows significant gaps between urban and rural/mountain areas. It offers good commercial and labour market integration (European Commission, 2017) due to its high level of infrastructure accessibility. In terms of innovation capabilities, this macro-region can be ranked as moderately innovative, given that two of the three regions (Alto Adige and Veneto) are considered moderately innovative and only Tyrol is ranked highly innovative according to the Regional Innovation Scoreboard (European Commission, 2018). With respect to the higher education system and the number of skilled workers available for the local labour market, despite the fact that the macro-region has high-quality universities and research centres, it is not appealing for graduates, who prefer to work in the surrounding geographical areas; for example, in the Bavarian region. The macro-region companies' level of technological adoption is well-positioned at the European level (European Commission, 2018).

3.3 Sampling and data collection procedure

This study used purposeful sampling to identify three key groups of stakeholders as follows: companies; organisations of public administration and organisations from the education industry, especially high schools, universities and research centres. The choice of these groups depended on belonging to the main categories of the triple helix model (Etzkowitz and Leydersdorff, 2000), according to which business/industry, academia/university and state/government can play an essential role as sources of innovation for regional development. Using personal networks, the researchers approached potential participants who fitted the criteria for stakeholders pertaining to each group. In this regard, given companies' key roles in the process of adoption and development of digitalisation in the regional system and the determination of the future level of competitiveness of the macro-region, as well as their high heterogeneity, we arbitrarily attributed a greater weight to this category in the composition of the sample (from 50 to 60 percent). Thus, companies operating in the manufacturing and tertiary industries, including companies focused on "Industry 4.0"; i.e. on specific technologies (Frank *et al.*, 2019) such as 3D printers, cyberphysical systems or the Internet of things, have been selected. Some innovative start-ups have been included in the sample, given the reallocation of profit between incumbents and new players induced by digitisation. The remainder of the sample was distributed between the other two categories of interviewees, with a slight prevalence of organisations of public administration (from 20 to 30 per cent) above organisations from the education industry (from 10% to 20%). Another fundamental selection criterion includes stakeholders that started internally or are involved

in digitalisation processes in the regional system. This sampling strategy ensured that there was logical generalisation and maximum application of information (Patton, 2002). Based on these selection criteria, a contact list of 100 stakeholders was created.

These 100 stakeholders were contacted via email. Of these 100 companies, 40 replied that they were not interested in participation due to their corporate policy, discretion or lack of time. Thus, 60 stakeholders, including companies (59%), organisations of public administration (24%) and those from the education industry (17%) were identified as eligible targets. Table 1 summarizes the profile of the interviewed stakeholders.

Appointments were set up for face-to-face semi-structured in-depth interviews with each respondent to obtain detailed information on their experiences. More precisely, 15 interviews were carried out in Tyrol (9 with companies, 3 with organisations of public administration and 3 with organisations from the education industry), 25 interviews in South Tyrol (13 with companies, 8 with organisations of public administration and 4 with organisations from the education industry) and 20 in Veneto (12 with companies, 5 with organisations of public administration and 3 with organisations from the education industry). Interviews were conducted between September 2018 and March 2019, each lasting from 1 to 2 h. Briefly, each interviewee was asked to identify the challenges that required more intervention to foster the digital transformation of the macro-region and to propose specific actions to be undertaken by the different actors. The interview protocol used for the qualitative analysis is reported in Table 2.

3.4 Data analysis

The interviews were audio-recorded and later transcribed and checked for accuracy. To examine the data, two different yet complementary analyses were applied. First, text mining analysis was undertaken to identify the strategic macro-areas of action (i.e. pillars) that respondents performed to face the digital transformation. Second, content analysis was undertaken to detect fields of action and specific strategic actions. More specifically, three pillars emerged from the organising texts into "lexical worlds" in a statistical and objective manner. Using IRaMuTeQ (interface R for the multidimensional analysis of the text and the questionnaires) software, correspondence factor analysis was used to identify homogeneous subsets of concepts in a given corpus of text in relation to their lexical profile. In particular, the stakeholders' interviews were categorised into a descending hierarchical classification from which it was possible to detect the three following classes (or "lexical worlds") that were representative of all discourses of the people who were interviewed: (1) "culture and skills", (2) "infrastructures and technologies" and (3) "ecosystems".

The corpus of analysis included all the interviews organised into a single file, which originated from 60 initial contextual units, one for each interview. The interviews questions were not included in the corpus of analysis; only the answers were kept in full, referencing the question. A revision of the entire file was conducted to correct typing and punctuation errors, standardising acronyms and joining compound words. Data processing was done using a greater number of compound words in the corpus. The use of this method is recommended to treat texts as they have been written or collected, without interpretation or coding by a mediator (Lebart and Salem, 1994), and to condense, classify and structure a large amount of text data to make it more understandable. This method made it possible to graphically identify the main thematic areas that the interviewees focused on. Figure 1 shows the factorial representation provided by IRaMuTeQ software.

Subsequently, content analysis was undertaken (Stemler, 2001) via qualitative solutions and research (QSR) NVivo 10 software. More precisely, two coding phases were implemented to identify strategies undertaken to successfully face the challenges of digital transformation. For the first coding phase, three scholars defined the list of codes following the categories

Table 1.
Profile of stakeholders interviewed

Stakeholders interviewed		Tyrol	South Tyrol	Veneto
Companies	No	9	13	12
	Types	business association, company networks and companies operating in manufacturing (automotive; machinery and equipment and metal products) and tertiary (logistics; telecommunications and consultancy) industries	business association, companies operating in manufacturing (automotive; electronic products; transport equipment and cement) and tertiary (road and rail transports; logistics; telecommunications; andconsultancy) industries	business associations, companies operating in manufacturing (spare parts; electric bikes and scooters; textile; iron and steel and clothing; finishing garment technologies) and tertiary (entertainment and amusement and IT and digital innovation consultancy) industries
	Interviewees	entrepreneur; CEO; chairman; marketing and export manager; vice-president; chief HR officer and strategic markets officer	entrepreneur; senior partner; managing director; CEO; chief operating officer; marketing manager and head of R&D department	entrepreneur; head of digital innovation; HR director; CEO; chief innovation officer; ICT and strategy director; marketing manager and digital manager
Public administration	No	3	8	5
	Types	public utilities, regional development agency	public utilities, municipalities, regional government, healthcare	public utilities (electricity, gas, cultural and tourism services and citizen services) and healthcare
	Interviewees	head of IT department, CEO	department director; head of IT department; former executive director; digital manager; CEO; coordinator	chief operating officer; energy division director; ICT director; administrative officer; HR manager
Education and research industry	No	3	4	3
	Types	Universities, employment agency	schools; universities; research centres; employment agency	upper secondary school and universities
	Interviewees	professors of innovation management and innovation economics and scientific director of a university	dean of the school, professor of ICT, rector and director	university manager and professors in economics, ICT or math and robotics

(1)	What are the main digitalisation challenges faced by your company (or public administration or organisation) and macro-region?
(2)	What is the readiness gap that you would attribute to each of them?
(3)	What are the key aspects that you would consider the most to fully exploit the innovation potential engendered by the digital age?
(4)	What are the main actions that your company (or public administration or organisation in the education industry) has undertaken or is undertaking to face these challenges?
(5)	Can you thoroughly explain how these strategic actions are undertaken? With which stakeholders did you collaborate?
(6)	What would you need to successfully face the digital transformation challenges?
(7)	What is the role of technology stakeholders in supporting the digital transformation?
(8)	How can this role be supported and enhanced in the future?
(9)	Are there any specific institutions/organisations that could be created or strengthened to better grasp the new opportunities offered by digitalisation?
(10)	Please provide us with the following general information: size, sector and performance (number of employees and industry – NACE code), information on the interviewee (current and previous position(s) and seniority), relevant market and business organisation (main source of competitive advantage, customer types and location, company structure, plant location, R&D investments, type of innovation and innovation outcome) and level of digitalisation (Eurostat Digital Intensity Index)

Table 2.
Interview protocol

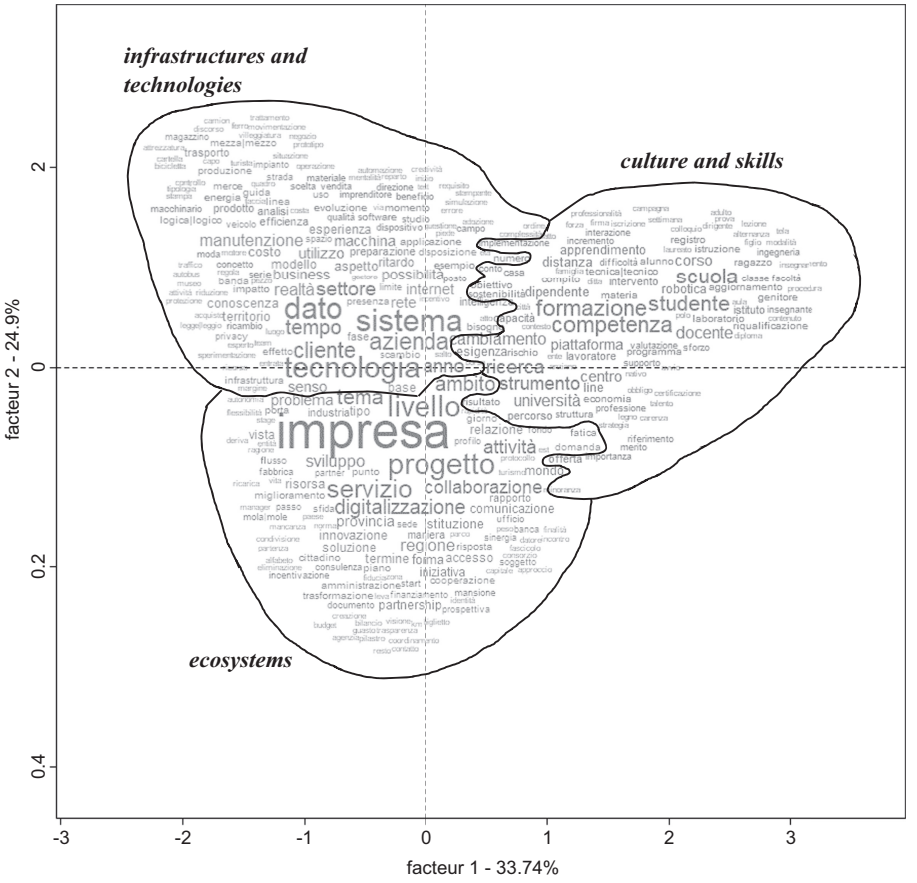

Figure 1.
Three strategic pillars emerging from content analysis

(or nodes) of strategies proposed by previous studies (open coding). From this first coding, which was performed separately by the three scholars, additional codes were added based on the inductive reading of the data (axial coding; see Saldaña, 2015). For the second coding phase, the merged code lists considering common labels inspired by literature and additional codes were used to analyse the interviews completed. The coding was conservatively undertaken, given that it included only what was explicit in the data. In other words, intentionality was not inferred in the data. The codes were clustered in more general analytical themes, which were used for the analysis. The themes were distinguished into the following two categories: (1) strategic fields of action and (2) specific strategic actions undertaken by stakeholders in terms of the macro-region development.

4. Findings

This section presents the strategies that emerged from the explorative investigation, which are summarised in Table 3. More specifically, they are proposed in relation to three pillars ("culture and skills", "infrastructures and technologies" and "ecosystems"), the key strategic fields of action and specific strategic actions.

4.1 Culture and skills

One of the challenges that the study interviewees perceived as particularly crucial was the development and updating of digital skills within companies, public administration and educational institutions. More precisely, new generations have a new approach to devices and have developed quasi-innate skills that offer great potential for companies when entering the labour market. In contrast, tenured workers have an increasing need to attend dedicated training courses, both within companies and in public administration. However, the teaching staff do not always have these skills and thus cannot pass them on to students or workers.

More generally, the interviewees argued that fostering digital transformation not only entails a major technological disruption but also implies the need to face a pervasive change that affects the overall economy and society. It requires a major investment in people to provide them with adequate knowledge and skills to better interact with emerging technologies in increasingly complex contexts. Consequently, in addition to the need to ensure a minimum threshold of literacy standards such as reading, writing and calculating, digitalisation requires the development of a fourth bundle of cognitive skills encompassing an appropriate set of abilities, attitudes and culture. In strategic terms, the interviewees highlighted the importance of leveraging the "culture and skills" pillar by investing in these three fields of action: (1) digital education, (2) talents and (3) digital culture.

4.1.1 Digital education. The interviewees suggest four strategic actions to be adopted in the field of digital education. First, they argue the importance of promoting digitalisation learning paths aimed at developing logical and computational skills. Due to the growing importance of digital transformation topics and their disruptive effects, these educational activities should be launched from the fourth year of primary school. Such a learning path will enable the younger generations to develop digital skills in a more natural and aware way to deal effectively with a future that will include permanently connected socioeconomic systems. In this regard, two professors of secondary school in Tyrol and Veneto stated the following:

> Since the first year of upper secondary school, we offer students an ECDL course, so that they can acquire at least the basics of using computers. Young people have a very high digital culture gap—when they enter the first year, they do not even know how to use Excel.

> Since the very early levels of education, the use of electronic devices will be part of daily life's normal activities, entailing the risk of unpleasant (i.e., spreading fake news) and sometimes even extremely

Key challenges	Pillars	Strategic fields of action	Strategic actions
Developing and updating digital skills within companies, public administration and organisations in the education industry	Culture and skills	Digital education	To promote digitalisation learning paths from the fourth year of primary school and to offer digital literacy courses to everyone
			To develop digital lifelong learning programs
			To create digital educational platforms
			To invest in e-learning
		Talents	To encourage talented and skilled workers to return, stay or transfer within the region by offering them perspectives
			To stimulate female students in the STEM professions
			To accompany towards new jobs, such as smart working
		Digital culture	To break down resistance to digitalisation through transparency-oriented behaviour
			To invest in reverse mentoring
			To create a "digital fit"
			To develop new digital business models through a far-sighted mentality
Continuously adapting to new digital technologies with cutting-edge infrastructures and services	Infrastructures and technologies	Information	To create fast networks by extending gig broadband and 5G and to implement infrastructures in the valleys and rural areas
			To create fast, reliable and secure networks that are able to protect data and guarantee the security of interconnected devices and their users
			To exploit the advantages of big data in SMEs
			To invest in e-government
		Interaction	To use collaborative robots (cobots) as helpers of human work
			To invest in autonomous production by developing AI
			To share data and knowledge
			To create barrier-free mobility
		AI	To define a strategic agenda in collaboration between stakeholders and AI experts from different sectors
			To use AI as a game changer in the analysis and use of big data
			To politically support AI development and to ensure the

(*continued*)

Table 3.
Strategies to face challenges of digital transformation

Key challenges	Pillars	Strategic fields of action	Strategic actions
			deployment of the potential of these technologies
			To invest in customer relations through AI
Developing synergies of medium- to long-term and innovative technological solutions involving different stakeholders of the public and private industry	Ecosystems	Medium- to long-term vision	To promote digital change as a continuous process
			To encourage citizens' involvement
			To leverage divergent thinking and diversity of opinions
			To operate in the direction of venture capital
		Partnerships	To develop digital campuses
			To encourage the networking of digital talents, start-up incubators, investors and scientists by exploiting start-ups
			To promote public–private partnerships
			To define the digital strategy in terms of open innovation
		Life quality	To leverage regional life quality
			To lower the cost of living in the macro-region
			To promote digital and sustainable solutions in all industries
			To generate virtuous improvement mechanisms in the area by supporting medium- to long-term sustainability policies

Table 3.

> risky situations (i.e. cyberbullying, sexting, abuse, identity fraud). Based on these issues, there is a strong need to support educational pathways allowing young citizens a fully aware use of the Internet as much as possible.

Meanwhile, public administrations emphasised the growing importance of training internal staff, who are often no longer young and typically need to acquire new skills that allow them to use digital technologies.

There is a growing need to educate all generations (teachers included) to deal with the ongoing challenges of the digital world. The dean of a secondary school in South Tyrol claimed the following:

> The teachers of the school must adapt their both general and specific skills, following the introduction of new digital technologies, when they carry out their teaching activities. Digitisation is part of the teaching of many technical subjects, but it also finds space in other subjects.

Second, the interviewees highlight that digital transformation requires the development of digital lifelong learning programmes to allow individuals to benefit from these programmes during their working and non-working lives. In this sense, the workplace can be used as learning place to offer permanent training to workers on digital issues, and training initiatives can involve the best possible collaborators in reskilling and upskilling activities. The scientific director of a university in Tyrol put this as follows:

> The micro-credit training courses (ECTS) could contribute to rapid professional updates on digital-related topics. Employees' willingness to engage in lifelong learning pathways is crucial and brings enormous benefits to companies. Because of that they should be supported in participating in such micro-training courses.

Third, the creation of a digital educational platform could enable the establishment of digital skills–oriented educational plans. To create such a platform, it is important to identify the labour market's most requested digital skills and maximise opportunities to match demand with supply. This aspect is clearly highlighted by a high school teacher in Veneto and by a manager of a business association in South Tyrol:

> The relationship between companies and institutions should be made institutional. . . A continuous technical update would be helpful for whom must prepare students to enter the labour market.

> Our association is going to extend its role as a platform by supporting new training interventions aimed at reskilling workers and enabling them to deal with changes in the labour market.

Fourth, it is crucial to invest in e-learning by educating people in the use of digital media and new technologies by both guaranteeing more time for teacher–student interactions and combining digital and analogue methods. The physical boundaries of such training activities are extremely flexible, creating much more interactive learning opportunities. Human relationships, however, are still considered as an essential prerequisite for younger students' educational growth, especially in universities. The rector of a university in South Tyrol pointed out the following:

> Online courses cannot replace profitable classroom discussions. However, if the educational offer is provided with high-quality up-to-date content, e-learning will find market space. This because modularity and flexibility represent the spirit of our time.

4.1.2 Talents. The second strategic field of action within the "culture and skills" pillar refers to talents, i.e. people with specific digital abilities and skills. It is undeniable that on the one hand, the availability of local talent is an enabling factor, but on the other hand, talent tends to concentrate in most thriving regions and cities. A real "talent war" is underway across European regions, particularly in the younger generations. The interviewees suggest four strategic actions to retain and attract talents within the macro-region. First, they argue the importance of encouraging talented and skilled workers to return, stay or transfer within the region by offering them perspectives, both personally and professionally, to facilitate the choice to live within the Tyrol–Veneto macro-region. The manager of a consulting company in South Tyrol argued as follows:

> A very special challenge is the lack of skilled workers in the Alps. This scarcity slows down the internal economy. In the Alpine regions many companies would be growing more significantly if they were able to find enough skilled workers in the labour market.

Second, the interviewees called for increased enrolment of female students in the scientific, technology, engineering and mathematical (STEM) professions to be achieved by offering them educational pathways and jobs that are compatible with their need for a work–life balance. The manager of a high-tech company in South Tyrol expressed this as follows:

> Girls are increasingly getting involved in technical subjects. We need to offer degree courses that are interesting for them. We also need to develop job opportunities capable of meeting young ladies' expectations.

Third, it emerges from the interviews that digital transformation is leading to major changes in the labour market causing, on the one hand, a potential loss of job and, on the other hand, the creation of new employment opportunities. It becomes, therefore, important

to accompany towards these new jobs. The head of public administration in Tyrol stated this:

> Thanks to digitisation, we can also target those who want to change jobs, optimise career goals, work-life balance and improve the quality of their work. Through IT tools technology could support people matching and profiling, according to their life paths and aspirations by relating them to companies expressed needs.

4.1.3 Digital culture. The third strategic field of action, within the "culture and skills" pillar, is named "digital culture". It basically refers to the need to create an open and positive mental attitude towards future technological challenges. Four strategic actions are thus identified. First, it is significant to be able to break down resistance to digitalisation through transparency-oriented behaviour aimed at motivating, involving and reducing information asymmetry about the digitalisation process. Notwithstanding this process is basically top-down, it is also true people's commitment and willingness to understand how exploiting innovative processes can successfully be used to implement change management strategies and improve organisational performance. The manager of a service organisation in Tyrol explained as follows:

> Companies must learn to self-motivate and motivate their staff. Employees must become aware that without a digitisation process their company will not survive. Therefore, they will have to become committed to their skill development.

Second, it becomes important to invest in reverse mentoring that refers to a situation where older executives and workers are paired with, and mentored by, younger employees on digital transformation-related topics. The purpose is to fill the digital gap through the contributions of different generations by encouraging the transmission of values, ideas, expectations and skills between managers and young talents. The manager of a service organisation in Veneto highlighted this as follows:

> I do not believe that creativity is exclusive to the young digital native. For me it's a mix of different generations and experiences: the old and the young adults together. That is the laboratory where ideas are born. Mixed opportunities for "clashes" between different generations are needed, because it is where added value is created. Bringing one expert together with young workers is strategic.

Third, the interviewees reveal that the intrinsic dynamism of digitalisation does not allow them to find an easy solution, especially within constantly changing, complex and unpredictable technological scenarios. It is therefore desirable to act by developing a series of dedicated studies aimed at reducing the existing knowledge gap.

Fourth, the time factor is emerged as crucial. If organisations operate with a short-term perspective, they incur the risk of reducing their competitiveness and thereby their long-term financial performance. Accordingly, the development of new digital business models requires a far-sighted mentality. The manager of a manufacturing company in South Tyrol argued as follows:

> Businesses should take the time to formulate their overall vision. We live in a deeply changing world. Every organisation needs to find its own business model.

4.2 Infrastructures and technologies

Another key challenge expressed by the interviewees was the need to continuously adapt to new digital technologies with cutting-edge infrastructures and services. Considering the specificities of the Tyrol–Veneto macro-region, the stakeholders sometimes perceived high gaps compared with leader regions in relation to some technologies although the potential for the region is not necessarily high. This was the case for smart factories and artificial intelligence, for which respondents felt the need to align the regional system with the

ongoing technological trends by developing synergies with other categories of actors. For other technologies, even high-potential ones, such as cloud computing, the need for action was relatively lower because the macro-region acts as a "user" of these technologies but not as a "developer". Finally, other technologies, such as collaborative robotics, were considered less relevant in light of the industrial composition of the macro-region; however, the large perceived gap justified the call for some form of action, according to 10% of the interviewees. There is also a missing precondition for exploiting the technological potential in many parts of the macro-region – the absence of broadband infrastructure, which does not allow for the collection and use of large databases, renders smart working difficult and inhibits the remote control of plants. Overall, the interviewees highlighted the importance of acting strategically within the "infrastructures and technologies" pillar by investing in these three fields of action: (1) information, (2) interaction and (3) artificial intelligence (AI).

4.2.1 Information. The interviewees suggest four strategic actions to be adopted in the field of information. First, they argue the importance of creating fast (high speed) networks by extending giga broadband and 5G also in remote areas as well as implementing an infrastructure system capable of supporting the development of start-ups also in the valleys and rural areas. The manager of a service organisation in Tyrol said this:

> ICT investments are needed to build a broadband network covering the whole territory. The absence of broadband in many parts of the region does not allow the use and collection of large databases, makes smart working difficult, and inhibits remote plant control.

The development of fibre networks, especially with "fibre to the home" (FTTH) infrastructure, is also considered as a key action for the advent of 5G mobile technology, whose adoption will start from 2020 and which will be a key disruptive technology for the digital future.

Second, it becomes fundamental that ICT infrastructure development embodies the continuous improvement of cybersecurity, given that the exchange of the most important sensitive data (e.g. company data, economic and financial information, health data) has a high value. The goal is to create fast, reliable and secure networks able to protect data and guarantee the security of interconnected devices and its users. In this context, digital technologies such as blockchain could play an important role. The interviewees not only highlight the importance of data security and reliability of the connection infrastructure but they also express a certain incapacity in facing risk situations (and cyberattacks). In this regard, the university manager in Veneto highlighted this:

> Often, we realise that we have suffered a hacker attack only after months, when our know-how has been stolen. On these aspects regarding security we tend to always attribute too marginal a value. This problem is not widely perceived at the collective level. Our entrepreneurs do not consider it a priority and therefore invest little.

Third, the interviewees suggest exploiting the advantages of big data in SMEs to segment the target market and customise their products and services through the exploitation of this enormous amount of data, as well as to optimise sales forecasts. However, the creation and daily use of insights and analytics based on the collection and use of big data is still underdeveloped at an organisational level and requires positive pressure to incentivise adoption by SMEs as much as possible. The director of a business association in Veneto argued as follows:

> The real value of big data lies in areas that are not traditional. Their greatest use is in the collection of economic-financial data, while the use and collection of industrial big data is still underdeveloped, that is, production data deriving from the machines used in the production process.

Fourth, another strategic action refers to e-government and specifically to the introducing an end-to-end digital one-stop shop for citizens. The basic idea is to minimise the gap between public administration and users by centralising the supply of a multiplicity of public services in a single place (physical or digital), providing citizens with the possibility of obtaining information and performing all operations at once. Finally, it would be desirable to draw up a "Digital Charter" that provides operational principles and guidelines to public sector employees. The manager of a municipality in South Tyrol expressed this:

> If a service is delivered with online access, it would be necessary to admit the presentation of all documents in digital form. Through blockchain, the procedure could be simplified, avoiding all the steps required by traditional transactions (e.g., notary). Blockchain has a high potential, but there is no legislation to be able to use this technology in document management (protocols, archives, etc.).

4.2.2 Interaction. The second strategic field of action within the "infrastructures and technologies" pillar includes networking interaction. More precisely, the interviewees suggest four strategic actions. First, they highlight the importance of using collaborative robots (cobots) as helpers of the human work, while in the long term, some work activities may be subjected to automation. A manager of a business association in Veneto said as follows:

> We have companies that have begun to buy anthropomorphs, like universal robotics, to carry out some operations. The gap is wide. It would be interesting to develop a study project to carry out stress tests on the potential linked to the use of cobots in a craft enterprise. Another element to consider is the security of their use.

Second, this study finds that it is necessary to invest in autonomous production, which will help master the volumes of data required for this purpose. The manager of a manufacturing firm in Tyrol claimed this:

> Our challenge is to digitise processes and implement them into a smart factory. This means translation of drawings and developments into an ERP system. An additional challenge is to connect with suppliers, because this requires good and solid planning activities. That's a very complex process, because all information has to be recorded accordingly.

Third, the interviewees suggest to share data and knowledge by calling for cloud solutions along the entire value chain. The manager of a manufacturing firm in Tyrol stated as follows:

> The challenge is to develop industry-specific know-how, based on existing data integration and interconnection. We partner with research centres and universities, but to identify a common shared technological know-how in our industry is not that easy.

Fourth, the stakeholders reveal the importance of creating barrier-free mobility by sharing data to optimise integrated mobility systems and supporting the adoption of specific technologies allowing seamless mobility (autonomous driving vehicles, intelligent systems for traffic management, bike and car sharing systems, etc.). The manager of a service organisation in South Tyrol highlighted this:

> Better big data exploitation necessarily relates to sharing data with other regions and comparing them. That would make it possible to analyse market trends on a much larger scale, grasp strategic implications, as well as formulating even more accurate forecasts of tourist flows.

4.2.3 Artificial intelligence. The third strategic field of action referred to the "infrastructures and technologies" pillar is AI because it is expected to provide businesses and regions with enormous business opportunities for territorial development and wealth creation. Four are the strategic actions suggested in this study. First, it is important to define

an agenda including a set of strategies and objectives to be achieved within a given time period. Given the complexity and sensitivity of this issue, it is appropriate that the development and adoption of these technologies takes place in a synergistic collaboration between stakeholders and AI experts from different sectors. Despite the huge potential and wide variety of applications of AI (e.g. resolution of social problems, safety, health, public administration, transport, customer relations), some interviewees expressed doubts and questions about the current awareness and the preparedness for AI in the macro-region. For example, the manager of a business association in Veneto stated the following:

> The issue of AI raises quite difficult questions about the future of work and brings up ethical and social issues. Specific knowledge is practically non-existent. There is still much yet to be discovered.

Second, it emerges how the advent of AI is considered as a game changer in the analysis and use of big data for the global competitive scenario, which currently sees the United States and China as the benchmark countries in the development of these technologies. As result of the continuous evolution of IA, it will be possible to find solutions to a large number of socioeconomic problems, such as medical record analysis, security, reduction of traffic congestion, security of citizens, customisation of products and services and process improvement. The manager of a multinational company in South Tyrol commented this:

> In the future, AI systems could make HRM processes more objective. In the recruitment phase, I see significant future applications for AI. More generally, everything related to testing, verification and comparison could be a potential field of application for AI.

Third, the interviewees call for a policy intervention to support the development of key AI technologies and training programmes aimed at creating innovative jobs in the macro-region as well as to ensure the deployment of the potential of these technologies. The country manager of company networks in Tyrol claimed as follows:

> In order to develop the skills of SMEs, it is essential to invest rapidly and massively in education systems. Even the best idea is useless for a company if nobody can do it. As many SMEs are faced with similar activities, clusters, joint cooperation and expert support are also useful to tackle the challenges together.

Fourth, this study highlights the importance of investing in customer relations through AI because it would allow SMEs to better understand, or even anticipate, customer needs and develop highly customised products and services. The manager of a publicly owned company operating in the energy industry in Veneto argued this:

> We are about to present a new machine learning model, developed thanks to an external partnership. We have made all our data available, carrying out a six-month test to improve output precision. They will get used internally for predictive operations on customer dropout chances.

4.3 Ecosystems

The third key challenge that emerged from the interviewed stakeholders referred to developing medium- to long-term synergies involving both private (e.g. start-ups, venture capitalists, large companies and SMEs) and public (e.g. public administration, universities and research centres) actors. To face this challenge, this study reveals the need to act within the "ecosystem" pillar by investing in the three following strategic fields of action: (1) medium- to long-term vision, (2) partnerships and (3) life quality.

4.3.1 Medium-to long-term vision. This research raises the opportunity to acquire a strategic vision to maintain the global competitiveness of the macro-region and its stakeholders. In the absence of a logic projected in a medium- to long-term period that considers the plurality of interested stakeholders, any intervention raises the risk of being

ineffective or at least not seeing its potential fully exploited. The interviewees suggested four strategic actions to be adopted in this field.

First, they highlighted the key role of top management in taking responsibility for promoting the digital change through constant updates. From this perspective, it would be important for top management to both acquire an agile and flexible organisational mentality and become able to adapt and innovate in response to the continuous changes in socioeconomic scenarios. The manager of a business association in Veneto stated the following:

> It would be necessary to encourage the introduction of the innovation manager—a figure with a strong managerial mandate—to embark on a digital transformation path. This process cannot be left to, for example, the intern. For example, managing social networks, communication and marketing are tasks that too often are underestimated.

Second, it is necessary to encourage citizens' involvement as much as possible, especially the participation of younger population groups, given that the future is being built today and these groups can actively and concretely contribute to the creation of tomorrow's society. The country manager of company networks in Tyrol claimed the following:

> In China, the weak regulation of the digital economy and the high public investments in future technologies based on a coordinated digital strategy offer start-ups and new digital business models the best conditions. Europe also needs a coordinated digital strategy in a short time, if it wants to keep up with the United States and China.

Third, it is important to leverage on divergent thinking and diversity of opinions to create a context that encourages, as much as possible, the birth of ideas and projects "from below" according to a bottom-up logic (open-minded culture). The manager of an organisation in the tertiary industry expressed the following:

> Companies need a new mindset to convince investors and motivate employees. This must be led by managers because it is part of the work strategy. It is not enough to reduce this aspect to financial management alone.

Fourth, the interviewees outlined the need to operate in the venture capital direction to invest in medium- to long-term projects and in unlisted start-ups with high growth potential. This activity is usually performed by institutional investors. Encouraging the creation of these investment realities in the Tyrol–Veneto macro-region could provide an accelerating boost to the success of innovation processes. Offering the most innovative and promising digital start-ups the possibility to easily access sources of venture capital financing helps avoid the use of traditional financing channels while also favouring the creation of more innovative enterprises. The company manager in Tyrol stated the following:

> In Tyrol, there is still not enough funding to rapidly guarantee the scalability of the projects. Not considering Silicon Valley as a reference, Dubai offers tax exemption in the early years, contributions for new offices, initial financial support and, if successful, only 10% of the value is due to the incubator. Here in Tyrol, the minimum funding amount is 10,000 or 20,000 euros. It is too little to allow the initiative to scale. Furthermore, in the post-design phase, further measures are needed to support start-ups.

4.3.2 Partnerships. The second strategic field of action within the "ecosystems" pillar refers to the partnerships that all stakeholders, especially SMEs, should form to fully grasp the opportunities offered by digitalisation. However, the ability to create solid and lasting partnerships that are aimed at building cooperative networks at a macro-regional level can encounter obstacles in territorial areas that are characterised by a strongly rooted, conservative entrepreneurial mindset. Moreover, digital transformation will lead to increased complexity, thereby rendering the development of innovative businesses and technologies

extremely difficult to undertake, if stakeholders persevere with implementing strategies based on an individualistic approach.

The interviewees suggested four actions to be adopted in this field. First, they suggested developing digital campuses because they viewed the universities of the macro-region as suitable hubs for the aggregation of companies, start-ups and talents. The campuses' main goal should be the creation of moments of mutual exchange, benchmarking and comparison, dissemination of research results, training and knowledge sharing. All campuses could encourage cultural contamination and the possibility of undertaking paths of mutual collaboration among academia, talents and businesses. An entrepreneur in Veneto highlighted the following:

> Companies often are unaware of the activities carried out by universities and research centres because there is a lack of dialogue and collaboration at the base. Most probably, the academic world is still considered as a mere training moment and not as a hub to accompany companies through meeting opportunities and much longer paths. If we consider that SMEs do not carry out research and development, it is normal to wonder how they can be able to better understand and exploit future trends.

Second, the interviewees emphasise the need of exploiting start-ups as a source of ideas for digital business models and encouraging their cooperation with talents, incubators and investors as a basis for digital innovation in SMEs. The president of a company in Tyrol stated the following:

> Companies that take advantage of the opportunities offered by digitisation can best meet customer needs, given that they can react more flexibly, faster and be more efficient in the use of resources. Digitisation and automation also offer the opportunity to alleviate the effects of the shortage of specialised personnel caused by demographic change. At the same time, new professional profiles are being created. In order to be able to actively shape and successfully deal with the transformation process that awaits us, businesses, training and research institutions and the public administration must create a strong network and together pursue an overall strategy.

Third, it is important to promote public–private partnerships to accelerate societal digitalisation, exploit cooperation with the most innovative and digital pioneering companies or start-ups and create global partnerships in response to digital complexity. The manager of a company in South Tyrol claimed the following:

> We feel the need for greater cooperation between businesses and the public sector to develop coordinated actions suitable for responding to the complex trends of digitisation and to share new solutions, generating new possible synergies for the whole territory. For this cooperation to develop, however, the policy maker must change its approach, abandoning the traditional one focused on restrictions and sanctions to seek shared solutions that do not exclude anyone.

Fourth, the interviewees highlighted the importance of considering European networks and open innovation in defining the digital strategy, as well as concentrating European funding on future digital issues. The entrepreneur of a manufacturing company in Veneto argued the following:

> It would be useful to put the various innovative companies in contact, perhaps by creating a pool of companies that interact with each other for the development of specific projects. An open innovation system would be needed from which to draw information, eliminating information asymmetries and creating synergies, involving certain start-ups. Many times, for example, we go hundreds of kilometres to find a company that offers certain technologies and, perhaps, we find out later that we have one within a few kilometres. This happens because there is not enough information on the projects being developed.

4.3.3 Life quality. The third strategic field of action within the "ecosystems" pillar is life quality, which is particularly important for this territory because regional innovation systems cannot sustain themselves over time if they are not accompanied by suitable living conditions for people and communities. The interviewees suggested four actions to be adopted in this field. First, they suggested leveraging life quality within the region to develop new business models, while simultaneously transforming the specificities of the regional lifestyle in strengths. The manager of an ICT company in Tyrol stated the following:

> Start-ups and young talents can only be attracted to the region if their interests are met. In addition to developing the business, they can also devote themselves to skiing, mountain biking in the mountains. The quality of alpine life is a differentiating factor compared to other regions.

Second, the need to lower the cost of living in the macro-region is increasing. The cost of living, alongside the variety and quality of services offered, should be considered an important factor as an excessively high cost of living could result in a "brain drain" scenario. By lowering the cost, with the same perceived quality, it could instead produce greater incentives to stay or even boost brain gain. The manager of an organisation in the tertiary industry in Tyrol claimed the following:

> In Tyrol, the War of Talents is made harsh by the proximity to Munich. This represents a major challenge for businesses in this region. From the point of view of Tyrolean companies, the lower wage levels and the additional burdens that aggravate the cost of labour are a disadvantage.

Third, it has become important to promote digital and sustainable solutions in all industries, from tourism to mobility to energy efficiency. The director of a university in Tyrol expressed the following:

> We have plans for the reuse of materials and slags in order to restore a function to the waste material. In educational terms, the university offers a master's degree in social design. However, stronger action would be needed, giving sustainability a higher priority.

Fourth, it is important to support medium- to long-term sustainability policies that respond effectively to the challenge of making relocating to the Tyrol–Veneto macro-region an attractive and convenient proposition for young talents, digital start-ups and highly innovative businesses. The manager of an ICT company in South Tyrol stated the following:

> Spending a few days in a beautiful region is not like living in a city with enormous possibilities for professional and personal fulfilment. Digital infrastructures, ad hoc incentives, capital and speed of response are needed to attract young entrepreneurs. I think the macro-region needs an institution that deals with it holistically. Small cities in small regions will only be successful if local issues are leveraged.

5. Discussion

The results of this study highlight that digital transformation is a pervasive technological change that affects and entails various challenges for a regional innovation system. In particular, the stakeholders interviewed for this research highlighted three challenges as follows: (1) the need to develop and update digital skills within companies, public administration and organisations in the education industry; (2) the need to continuously adapt to new digital technologies with cutting-edge infrastructures and services and (3) the need to develop synergies of medium- to long-term and innovative technological solutions by involving different stakeholders of the public and private industry. These results also indicate that there is no single and univocal strategy to face these challenges but that digital

transformation requires a multifaceted set of strategic actions to be fostered, as argued by Schmidt *et al.* (2018). In this study, these actions were divided into three pillars.

The first pillar underlines the importance of developing a mix of culture and skills that can positively influence the digital transformation path. In this regard, this research highlights the importance of creating training courses capable of enhancing talent and more generally spreading digital culture to sustain the economic growth and foster the international competitiveness of the macro-region, as argued by Cohen (2010).

The second pillar highlights that the challenges imposed by digitalisation require technological innovation and investments in ICT networks as well as multidimensional interventions to support them. In this respect, it focuses on the role of infrastructural and technological development as a means of promoting the flow of information, creating inter-industry interactions and increasing the development of AI. Notably, the rapid availability of large quantities of data and information will require the rapid spread of 5G infrastructures and the expansion of broadband in the peripheral areas of the macro-region. This will make possible an increasing sharing of data between the various stakeholders of the regional system and the creation of digitally integrated supply chains. These interventions must be accompanied by increasing protection of the security of such data and information and by widespread awareness of the risks that may arise from their non-responsible use.

The third pillar refers to the creation of digital ecosystems for virtuous territorial growth. To move in this direction, partnership-based strategies are needed to implement digital-based business models and stimulate co-creation processes. The new partnerships will involve SMEs, called to collaborate not only with other SMEs and research centres but also with large companies, which in turn will increasingly rely on the creative force of start-ups to develop innovative technological solutions. The interviews also underlined the need to develop a model of technological innovation and knowledge management based on collaboration between companies and the other components of the regional innovative system. This model would allow the recombination and integration of knowledge and technological domains developed individually to form new digital platforms (Kenney and Zysman, 2016; Cenamor *et al.*, 2017). This result aligns with the literature that recommends that organisations think increasingly about themselves as the node of a wider innovative ecosystem and view partnerships as the main tool to successfully face the challenges of digitalisation (e.g. Nambisan *et al.*, 2019; Parida *et al.*, 2019). Identifying these priorities and their declination in the territorial context must be followed by a proposal for idiosyncratic innovative paths based on the specific features of the macro-region and suitable for enhancing its vocation in terms of both knowledge and entrepreneurship, as well as social and cultural resources to face digital transformation. In other words, the results of this study highlight that digital ecosystems cannot be explained only by examining companies' strategies and performance (e.g. Evangelista *et al.*, 2002; Evangelista *et al.*, 2018). Other actors play a key role in favouring the development and economic exploitation of knowledge, such as networks among firms, public administrators and the education system (e.g. Edquist, 1997). In the era of smart working, the regional ecosystem could also leverage quality of life as a strategic asset – both to counter the phenomenon of brain drain and to attract innovative talents and organisational realities.

A macro-regional policy for digital transformation should operate in these three directions without focussing its attention only on technologies or considering only one technology at a time. Moreover, the various strategic actions must be coordinated with each other. For example, actions related to big data and AI are both centred on the problem of poor access to research centres and knowledge brokers and the lack of qualified personnel. Public administrations that focus on big data complain about the lack of overall vision and the scarce systematisation of the already available information. Universities

and educational institutions instead emphasise the importance of AI and the difficulty of positioning themselves at the frontier of research in using this technology. Thus, there is a widespread perception that individual interventions would be unable to reshape the industrial system and allow the macro-region to remain competitive during the future technological waves induced by digitalisation. This perception is evidently affected by the economic and geographical characteristics of the macro-region, characterised by large portions of the mountains and remote areas and by an industrial fabric focused on medium-tech manufacturing industries that characterise the macro-region. Therefore, these results cannot be generalised. Further research could undertake a quantitative empirical study on a larger scale and compare the results with surveys conducted at national and international levels. With a larger sample, more detailed analyses could be performed and highlight possible similarities and differences from a cross-national and cross-cultural perspective.

6. Implications

6.1 Conceptual implications

This research contributes to the existing literature in the following four ways. First, it outlines the value of a multi-stakeholder approach to analyse strategies that companies, public administrators and organisations in the education industry can undertake to successfully face the challenges of digital transformation in a regional innovation system.

Second, this study highlights the contribution of individual stakeholders to digitalizing a macro-region and, more generally, a regional innovative system. In the future, scholars could investigate in further detail which stakeholders should invest more and in what ways, to foster digital transformation at regional level.

Third, in accordance with Schmidt *et al.* (2018), this paper empirically highlights the importance of examining the case of moderately innovative regions because they can provide interesting insights in the digitalisation field for strategic management scholars. In this sense, this research suggests not only focusing on clusters, regions or neighbourhoods that are considered leaders in digitalisation.

Fourth, this study outlines that like all economic phenomena, digitalisation is based on people (Dini *et al.*, 2011). Only through investment in the people who work in the macro-region or the people who will relocate there can the regional innovation system successfully combine the adoption of new digital technologies with innovative processes and products that enhance the specificities of the territory, thus promoting the sustainable development, competitiveness and social progress of the macro-region as a whole.

6.2 Practical implications

This exploratory study provides different practical implications to managers and executives of companies, public administration and organisations of the education industry, as well as policy makers, to face the challenges of digital transformation.

In general, the results of this research suggest a path to foster digitalisation in a moderately innovative macro-region by developing digital culture and skills, before investing in digital infrastructure and technology. Culture and skills are essential prerequisites for building new human–machine relationships as the basis of the digital economy. These relationships cannot be taken for granted, and it is not possible to achieve digital transformation in their absence. Of course, the dynamics of digital change require cutting-edge infrastructure and services. However, knowing how to exploit new technologies and the advantages of big data, as well as how to use AI in data analysis, is insufficient. Thus, acquiring the necessary knowledge and skills should be considered and

developed as a founding trait to successfully face the digital revolution in the macro-region of interest. It is also clear that implementing these strategies requires courageous and coordinated choices and actions that systematically involve all stakeholders at the macro-regional level. Accordingly, the macro-region should leverage its "regional knowledge domain" to develop a specific set of actions and create the conditions needed to take full advantage of digital transformation. The actions must involve all generations, covering both the digital literacy of the youngest people and the training of adult workers (lifelong learning). These actions must be accompanied by the offer of adequate prospects for young talents and an orientation towards gender equality. In this sense, the results of this research confirm that digital transformation is a pervasive phenomenon that affects the overall economy and society.

When considering single stakeholders, the results advise all types of companies to reconfigure their business models by acquiring a new mentality oriented towards a medium- to long-term perspective. If companies focus on short-termism, the risk of limiting the birth and implementation of new digital business models becomes high. In the future, this could generate a competitive inability or significant reduction in organisational and economic–financial performance and, in turn, depress the socioeconomic context. In addition, this research invites companies to invest in smart working in terms of telework to increase the quality of work and reduce some cost items. Another recommendation, targeted to large companies, is to establish contacts with start-ups because this represents for them an opportunity to create new partnerships while also offering an opportunity for start-ups to collaborate and strengthen their network. At regional level, the dialogue among various companies should create a benchmark on the various experiences and enable identification of a series of clusters of companies that produce similar products and services. Subsequently, a platform should be created and made available to all companies.

In addition, this research recommends that public administration mainly invest in two strategic fields of action as follows: digital education and partnerships. Public administrations should train internal staff who are often no longer young and typically need to acquire new skills that allow them to use digital technologies through dedicated training courses. Furthermore, public administrations could better exploit smart working as a tool aimed at increasing the quality of work and collaborative engineering that allows, for example, people dispersed in the territory (and belonging to different organisations) to collaborate in developing the same project. Another area in which partnerships have high potential is matching demand and supply in labour markets.

With reference to the educational institutions industry, the results stress the importance of developing and updating digital skills within training systems. Universities should train young students with new ideas and skills in the digital field; however, to move in this direction, it is fundamental to develop a clear strategy for digital skills. This could mean starting new collaborations with external subjects, especially with companies, not only to enrich the students' curriculum but also to develop projects and access additional sources of funding, as well as to define a curricular proposal that makes STEM disciplines attractive for females and foreign students.

Finally, this study invites policy makers in the regional innovation system to develop a two-tier intervention centred on the following aspects: (1) develop the education system to make it capable of promoting digital literacy and raising students' awareness of the dangers of the Internet and (2) develop collaboration between stakeholders to identify potential lifelong learning pathways. It is obvious, but not for this trivial, that policy makers should make more financial resources available. Concentrating more funding is fundamental to encourage digital transformation processes as much as possible in the stakeholders' activities of the macro-region. In regard to institutional change, this study points out the importance

of –and at the same time invites at – fostering "table talks" as strategic and policy actions to support dialogue between all macro-regional actors.

7. Conclusions

The challenges imposed by digitalisation require multidimensional interventions embedded in the specific features of each regional innovative system to enhance the vocation of each local context in terms of knowledge, entrepreneurship and social and cultural resources. Thus, each regional innovation system must develop its own original path that relies on its technological and cognitive base, as well as underlying resources and skills, to effectively seize the opportunities offered by digital transformation to support business competitiveness, create quality jobs, promote the sustainable development of the territory and redefine the relationships between the public administration and citizens.

The contribution of this study refers to the strategies that can be undertaken to successfully face the challenges of digital transformation by considering the ongoing dynamics within the macro-region of Tyrol–Veneto. In particular, this research proposes that a macro-regional policy for digital transformation should operate in three directions – to develop digital culture and skills, create infrastructures and technologies and invest in digital ecosystems. These strategies could be adapted to other regions and used as a reference point in terms of business, market and local development.

The numerous strategic actions emerging by this research highlight that it is not easy to study (or implement) digitalisation because this is like trying to understand (and apply) a revolution while it is occurring. Many things change, and they change so fast that it is hardly possible to realise what the next stages will be like. Yet, although it is impossible to foresee the outcome of such an evolution, one can gain some useful insights to make better sense of what is happening and to promote a development-oriented use of digitalisation while preventing a short-sighted exploitation.

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