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Sustainable development, intellectual capital and technology policies: A structured literature review and future research agenda

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ABSTRACT

This paper aims to provide a Structured Literature Review (SLR) about the strategic role of Intellectual Capital (IC) for achieving Sustainable Development Goals (SDGs). It offers an outline of past and present literature and frames a future research agenda. It analyses papers published in journals from 2003 – 2018 with the aim of deriving significant insights about IC's determinants for achieving SDGs. Although empirical and theoretical studies have shown a positive relationship between IC and sustainability, the research remains an emerging area of growing importance. Although no explicit specialisation in the topic currently exists, findings highlight the "sustainability imperative" and convergence toward the following research areas: *IC components for Sustainable Development in Private Sector, IC for Sustainable Regional Development in the Knowledge Economy, and IC for Sustainable Development in the Public Sector.* Discussions indicate that some SDGs are starting to be explored more than others (e.g., quality education, infrastructure, health, cities and communities) and that only recently some studies are specialising specifically in the importance of technology to address the SDGs. Implications for technology policy have been highlighted to frame a future research agenda for academics and practitioners.

1. Introduction

The topic of sustainability and sustainable development has recently gained importance on the agenda of academics and practitioners. This is due to the relevance and dissemination of the report published by the UN World Commission on Environment and Development, known as the Brundtland Report (Brundtland, 1987). An accepted definition identifies its three main pillars: economic, social, and environmental sustainability (Wasiluk, 2013, p. 103).

The topic of sustainability also gained more attention due to the 2015 launch of the United Nations 'Sustainable Development Goals (SDGs)' 2030 agenda. It consisted of global and universal indicators for international cooperation as well as for the collaboration of civil society, governments, multilateral institutions and the private sector (Nam, 2015). The Sustainable development framework includes 17 SDGs that embrace a wide range of environmental, social and economic issues, including climate change, energy, biodiversity, food supply and security, sustainable production and consumption, healthcare, education, gender, equality, peace and economic growth (Gupta and Vegelin, 2016). The goal of sustainable development is to find the effective solutions for some complex challenges and issues such as energy, climate change, pollution, migration, ecosystem resilience, food security and many others that require a cross disciplinary perspective (Suciu and Nàsulea, 2019, page 73; Birtchnell et al., 2017).

Within this debate, some scholars began to consider Intellectual Capital (IC) an important link between support needs and development needs to fulfil the SDGs (Suciu and Nàsulea, 2019; Massaro et al., 2018). Several studies argue that IC is the most powerful economic production engine and the most important driver of smart, sustainable, inclusive, economic and social development (Matos et al., 2017; Suciu and Nasulea, 2019).

The term IC, coined for the first time by Machlup in 1962, with the aim to highlight the importance of general knowledge as essential to growth and development, has become the focus of researchers and academics in recent years, especially with the arrival of the knowledge based society (see, Drucker, 1993; Sveiby, 1997; Edvinson and Malone, 1997; Bontis, 1996, 1998, 2003). IC has been described as intellectual material that has been formalized, captured and leveraged to produce a higher valued asset (Klein and Prusak, 1994). An interesting conceptualisation sees IC as the combination of intangible resources and activities that allow an organisation to transform a bundle of material, financial and human resources into a system capable of

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creating stakeholder value (European Commission, 2006). In particular, IC can be thought of as three categories of intangible assets of a company: e.g., human capital, organisational capital (or structural capital), and relational capital (also social capital or customer capital) (Stewart, 1997; Bontis, 1998). IC sustains and drives value creation dynamics (Schiuma et al., 2007). According to Dumay (2016, p. 169) IC 'values' encompass not only monetary value, but also 'value' created in terms of the usefulness of the goods and services that organisations produce (utility), the benefits provided to society in general (social) (Nahapiet and Ghosal, 1998), and the impact on future generations (sustainability) (Dumay, 2016). The concept of value includes economic utility, social worth and environmental value (Dumay et al., 2017).

Furthermore, with the widespread use of technological applications and the advent of the digital era, IC has a significant impact on economic growth and social development, based increasingly on knowledge and innovation. Managing and introducing IC practices has become a decisive factor for competitiveness, reputation, richness and sustainability, which focus on citizens, quality of life and the contribution to a more sustainable society (Matos, et al, 2019). Therefore, an overlap between sustainability and IC (Wasiluk, 2013, p. 104) emerges as they "both highlight that organisations need to develop new understandings of how to create and exploit their nonfinancial resources." Accordingly, academics and practitioners are focusing on exploring the relationships between IC, sustainability and competitiveness of companies, cities, regions and countries (Massaro et al, 2017).

Recently, the debate and research on IC has reached the 'fourth stage' of research (Guthrie et al., 2012) that extends the boundaries of IC to include a wider ecosystem (Secundo et al., 2016). Therefore, the fourth stage of IC research shows particular attention to sustainability issues, as it also deals with "paramount ecological, social, and demographic problems that our societies are facing" (Dameri and Ricciardi, 2015, p. 861). Such research developments are sketching an intersection between sustainability and IC, as they both focus on understanding and analysing the interrelations between IC and the pillars of economic, social, and environmental sustainability (Massaro et al, 2017).

Among IC's main components, different studies have suggested the leading role of information communication technologies (ICTs) for sustainability in delivering multiple benefits to society, thus contributing to achieving SDGs (Charles Steinfield, et al., 2010; Wu et al., 2018). It has been argued that the ICTs' pervasiveness plays a relevant role in addressing societal and sustainability challenges in areas such as health, energy, and transportation, fostering excellence in the science base (Research Infrastructures), and promoting leadership in traditional and high-tech manufacturing sectors (robotics, photonics, micro- and nanoelectronics) (European Commission, 2015).

However, access to technology in isolation does not result in achieving SDGs (Söderholm et al, 2019). What is being often overlooked is the interrelation between technological infrastructure and organisations or countries' capacity to exploit and mobilize the technology to create value and advantage by facilitating knowledge exchange and spurring innovation. In achieving such outputs, IC management is being considered a central resource (Martin et al., 2018; Mertins and Orth, 2012, Cavicchi and Vagnoni, 2017; de Leaniz and del Bosque, 2013) as it concentrates on the dynamic interrelation of human, structural and relational capital for maximising sustainable performance.

Despite the evident interrelation between IC and sustainability the comprehension of its impact on achieving SDG goals is still under researched and analysed from fragmented perspectives. Accordingly, there is a need to comprehend the literature's state of the art regarding sustainability and achieving SDGs through the strategic role of IC.

This raises a need to better understand the meaning of IC as the most promising strategy enabling achieving 17 SDGs to derive implications in terms of technology policies.

Accordingly, this paper reviews and critiques the IC and SDG literature, to provide an overview of the state of research on the topic and to outline a future research agenda.

To perform such research this paper uses a structured literature review (SLR) methodology, as proposed by Massaro et al. (2016). It also extends the SLR approach through the use of keyword analysis (McCulloh et al., 2013; Ribiere and Walter, 2013) and the inclusion of more detailed content-driven analysis to further develop findings.

It has been extensively argued that conducting an SLR "can help experienced scholars develop new and interesting research paths by accessing and analysing a considerable volume of scholarly work" (Massaro et al., 2016). The use of SLR has been successfully adopted in different research fields (Massaro et al., 2015b; Guthrie et al., 2012; Dumay and Cai, 2014; Centobelli and Ndou, 2019).

The findings of a Structured Literature Review (SLR) show the existing literature's focus primarily on three research areas: 1) IC components for Sustainable Development in the Private sector; 2) IC for Sustainable Regional Development in the Knowledge Economy, and finally 3) IC for Sustainable Development in the Public Sector. These results highlight the partial comprehension of the phenomenon observed and are a useful baseline for implications in terms of technology policies that could support the evolution and achieving SDGs at global level. Finally, a future research agenda is framed for sketching out the IC role for SDG achievement, with particular reference to ICT and other technologies' potentialities. The results and implications of this study inform practitioners and academics about the main evolution of IC and SDGs, providing some insights about future research needs.

The remainder of the paper is structured as follows: after the introduction, in Section 2 the methodology is detailed. Section 3 presents the SLR's findings in terms of descriptive statistics and content analysis. Discussions, conclusions and implications are detailed in the final sections.

2. Methodology

To achieve the aims of this study a structured literature review (SLR) is performed. SLR is considered an appropriate approach able to contribute in identifying research trends and future potentialities (Massaro et al., 2016; Petticrew and Roberts, 2006; Tranfield et al., 2003). More recently, SLRs has reached significant progress going beyond simply summarising and deducing prior researches, due to the wide availability of academic papers (Massaro et al., 2016).

Previous studies suggest different approaches and steps to be followed to appropriately identifying relevant articles to review (Dumay and Cai, 2014; Massaro et al. 2015a, 2015b; Christoffersen 2013; Thorpe et al. 2005). To perform a systematic, transparent and replicable study the SLR needs to follow some specific steps (Massaro et al. 2016), such as the definition of research questions, research protocol, papers and coding framework as well as the type of analysis to perform.

According to Massaro et al (2016), the first step in performing a SLR is to establish the research questions. Three main RQ need to be formulated: How is the literature developing? What is the literature's focus on the issue? And what are the implications of research? Regarding this, the research questions in this study are formulated as follows:

RQ1. How is the *Sustainable development* literature developing according to an IC perspective?
RQ2. What is the literature's focus within *Sustainable Development and IC*?
RQ3. What are the research implications in the fields of SDGs, IC and Technology policies?

The first research question is intended to provide a specific state of the art of literature on the issue as well as explaining the extent to which the literature is considering the argument.

The second research question is more linked to defining the perspective from which literature has been developed so far and which main keywords and specialisation emerge from the literature considered.

The third research question is more inferential, meaning that it helps the researchers to discuss and provide insights.

In addition, the *research protocol* is necessary for determining which source of information to use, which methods, means and tools to apply for exploring and summarising the studies (Petticrew and Roberts, 2008).

A further step to follow is to *determine the papers* to include for a comprehensive literature search. We focused on Scopus database for identifying the articles to be included. This choice is coherent with previous studies argument which concurs that Scopus database provides extensive coverage of academic journals as it embraces more than 20,000 peer-reviewed journals (Mishra et al., 2017) and it is more abundant than Web-of-Science (WoS) database (Thelwall, 2018). In addition, the papers indexed in Web of Science (WoS) are almost included in Scopus database as well (97%) (Waltman, 2016). Therefore, using Scopus database is a suitable data warehouse for performing structured literature review.

The next step consisted in developing the *coding framework* based on similar research frameworks. For the scope of this study we defined the following categories for coding:

- *Timing of publication:* Nr. of papers published over time.
- *Geographic distribution of papers*: papers distribution among countries.
- *Journals:* Distribution of papers among journals and citations received.
- *Author and Citations analysis*: Number of citations, citations per year, Citations and collaborations among authors.
- *Relevant Keywords and topics:* The type and frequency of keywords used and the emergent topic areas.

Finally, a *critical analysis and discussion* of the results obtained is necessary. In this study, a SLR and bibliometric analysis is performed to decrease errors. Previous studies recommend combining these two methods to enhance the value of the research outcomes (Feng et al., 2017; Fahimnia et al., 2015).

To select appropriate papers to include in the study, we defined search strings by querying a set of relevant keywords. The keywords and combinations identified and used for the paper search were "Intellectual Capital" AND "Sustainable Development" OR "Technolog*", in the title, abstract, author keywords, author(s), number of citations, year, affiliations, source & document type.

In SLR, selection bias arises when considering the topic's scope. If it is broad and hard to define, relevant articles risk being excluded. However, SLR literature presents methods to reduce such risk. These methods lie in the protocol used to perform the SLR. Petticrew and Roberts (2006) argued that the standard protocol's aim is to reduce the false negative and, at the same time, increase the false positive as much as possible. Starting from this, Reed and Baxter (2009) stated that: *"Classically, we strive for high precision to recall a maximum of hits (relevant sources), a minimum of false positive (identified but irrelevant sources), and very small number of false negatives (relevant sources not identified) to maximize efficiency. In research summaries, however, the paradigm is different. Because the goal is thoroughness (completeness), the primary need is to reduce the number of false negatives (relevant sources not identified), so the research summaries must be willing so examine a larger number of false positives."*

In the case of this article, we followed the PRISMA protocol, which precisely confirms what was highlighted by the aforementioned authors. Therefore, we chose the KWs mainly covering the largest scope of IC and SD. We deem our results robust for several reasons:

1 We queried the string of KWs in both Scopus and WoS. We found that all items coming out with WoS were included in the Scopus dataset, which was then much larger. So we used the Scopus dataset.
2 Our focus was on SD and IC and related linkages, then the use of these two KWs linked to each other was substantial to define the boundaries of our search. In querying databases, this linkage runs with the command "AND." However, to avoid false negatives, we also performed the selection with the command "OR." Results led us to the same selection.
3 Our aim was to deliver an inventory of papers concerning a specific research area. That document list also needed to be relevant. To assess the relevance, we considered the impact in terms of citations weighted by years lagged in time, as usual. We used this restriction to rule out items not influencing the development of the research areas over time.
4 In building the panel of relevant articles, we were interested in identifying a first grouping of items. To do so, we performed the cluster analysis excluding papers clustering alone. The cluster criteria were the existence of a third common article in the references of two compared papers. However, to improve our results' robustness, we read the papers excluded by the clustering procedure. Once again, results led us to the same selection.

All these reasons support the need to reduce the selection bias, which actually occurs in different stages of our workflow to obtain the dataset to progress towards analysis.

This way of searching for papers is reproducible and comprehensive. As first result, a total of 1520 papers were recovered. Data were collected in January 2019 - February 2019.

We considered only journal papers published up to 2018 (inclusive) and we excluded conference papers, book chapters, research notes, editorials, and commentaries (Keupp et al., 2012).

Also, to obtain a more suitable set of papers, we defined some inclusion and exclusion criteria.

Three researchers were employed in reading the papers' abstracts and titles to identify the pertinent papers for further analysis. Specifically, selection of items was performed following the steps displayed in Fig. 1:

1 1520 items were downloaded from Scopus database, after setting the keywords.
2 535 items were excluded due to being conference paper/book/book chapter/short survey.
3 887 articles were excluded after reading titles and abstracts, due to the fact that only 98 out of 985 matched at least one of the topics of intellectual capital/sustainable development/technology.
4 Searching the articles considering IC in a pair with Sustainable Development or Technology. This led to the exclusion of an additional 47 articles, so that we kept only 51 articles in the study for further analyses.

The data analysis consisted first of all of some descriptive analysis such as distribution of articles among countries, aiming to underline how literature supports the development of a scientific discourse within specific national settings (Massaro and Dumay, 2015a). In addition, as suggested by Dumay (2014), measures were also performed related to analysing the impact of the citation index (CI), the citations per year (CPY), as well as citations and collaborations among authors. For analysing the keywords, we performed occurrence analysis that permitted identifying the most relevant and used ones.

Articles were coded manually by author, using other research team members to solve discrepancies in coding. Manual codes were checked using text search queries to increase the results' validity. Following the coding, data were analysed by using VOSviewer, a tool for constructing and visualising bibliometric networks and clusters (Van Eck and Waltman, 2014).

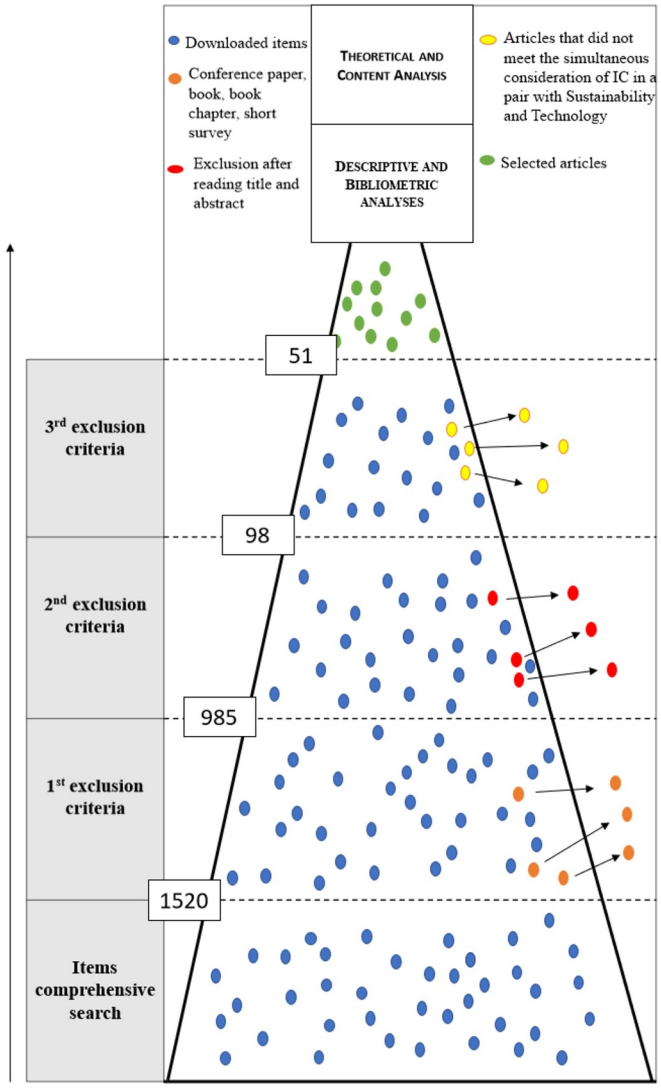

Fig. 1. Article selection pyramid.

Thus, data were processed by following different techniques (van Eck and Waltman, 2017):

- Co-occurrence (Eck and Waltman, 2009) – the articles' relatedness is assessed based on the number of articles in which they occur together, using the author's keywords as unit of analysis. We set the software to include papers in which keywords occur 3 times at least.
  - Bibliographic coupling (Kessler, 1963) - the articles' relevance is based on the number of references they share (Boyack and Klavans, 2010). Unit of analysis: Documents: the pertinence is evaluated considering those papers that mainly share the same references. If it is, they cluster. Each cluster contains the papers that may mark a specific theme/topic. The software was set to consider papers with at least 1 citation

The fractional counting is used for all the analysis performed with VOS viewer (Leydesdorff and Opthof, 2010).

As argued by (Van Eck and Waltman, 2014) the clustering technique is appropriate for performing bibliometric analysis by VOSviewer developers, as it refers to distances between nodes, and therefore groups/clusters are determined by minimising such distances. Additionally, networking technique is proposed following the consolidated literature (Newman, 2004).

Finally, a content analysis is performed with the purpose of grasping the emerging trends and research gaps as well as for identifying future directions. The main findings are presented and discussed in the next section.

3. Research findings: insights and critique

This section aims to present the results obtained from the analysis that answer the first two research questions of this study: RQ1. How is the *Sustainable development* literature developing according to an IC perspective? And RQ2. What is the literature's focus within *Sustainable Development and IC*?

Accordingly, this section is organised into two main parts: descriptive and content analysis.

3.1. Descriptive analysis

3.1.1. Articles' evolution in time

Fig. 2 displays the number of published articles over the 2005-2018 timeframe. By reading Fig. 2, the trend in the number of published articles appears to be growing over the considered 2005-2018 timeframe. As shown by the figure, the first articles (5) date back to 2005, and from that date to 2010, scholars only published three articles. By contrast, from 2011 on, the interest regarding the topic of IC linked to related technologies and sustainable development revived, so that in 2013 there was a first peak of developed articles (7). This number was doubled in 2018. Hence, along the considered timeframe, the highest peak of published articles was reached in 2018. This data may conceal that scholars deem this topic relevant for deep exploration in future studies.

The findings related to this issue demonstrate how the literature on IC and SDG began to flourish in recent years. Very few contributions are provided before 2010, and the correlation and co-citations between authors is also very low. This again explains the studies' fragmentation related to such inter-relationship. The somewhat high number of articles in recent years is related to academics and practitioners' greater awareness on the issue.

3.1.2. Geography of the articles

To analyse the articles' geography, we considered the distribution of articles per country (Fig. 3), the number of citations per country and number of cited articles per country (Fig. 4). The count was made by considering the involvement of a country (by university/research institution) in the articles' authorship: if an article was developed by cooperation of different countries, each country received one point. So, this geographical investigation just helps understand which countries have ever shown interest in studying the topic of IC linked to sustainable development.

Specifically, we found that:

- The top three countries are represented by Romania (9), Spain (9) and USA (7). As the overall number of selected papers is low, 19 out of 28 countries have only one article, and 5 out of 28 with two articles.
- The top three numbers of citations belong to UK, USA and Switzerland, respectively. Once again the works published in 2005 led the rank, driven in this case by geographic location. This data refers to Table 1, which shows the references of the top three cited papers and related countries involved.
- From the number of cited papers per country, Romania disappears, although it is on top of the ranking in Fig. 3. Other results just note that the dominant positions are held by UK, USA and Spain.

These findings again explain the studies' fragmentation among countries. Up to now, no country is specialised in the topic.

In addition, the journals where the articles are published belong mainly to the areas of Business, Management and Accounting and

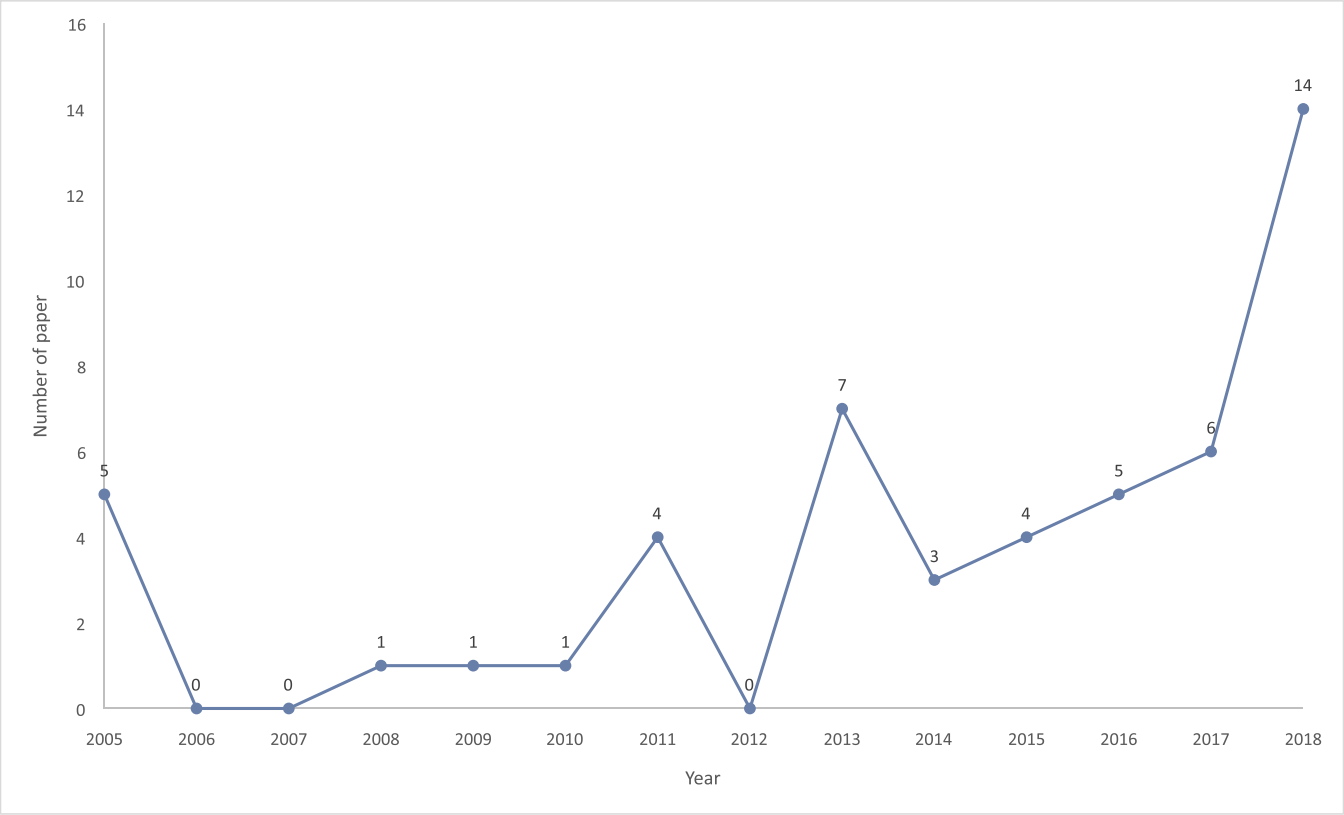

Fig. 2. Trend of the published articles over the timeframe 2005-2018.

Economics, Econometrics and Finance (according to Scopus classification). The other articles are published in journals that belong to different areas such as engineering and social sciences, without a specific specialisation. This could be evident since the argument of SDG is broad.

3.1.3. Journals

Where articles are published is an important indicator especially for prospective researchers and authors (Dumay and Cai, 2014). Our research indicates that the total amount of published articles in journals is 51, indicating that the topic has great unexplored potential.

A different consideration arises from focus on the source of the most influential articles. As shown in Tables 1 and 2, four journals consistently have the largest citations and CPY (*Sustainable Development, R and D Management, Technovation, Journal of Intellectual Capital*). The influence may come from the specific article and not the relative journal.

However, owing to the relatively small number of published papers, it seems that the research will need to make a significant contribution to both IC and SDG knowledge.

3.1.4. Citations and most influential authors

Fig. 5 shows that, by virtue of citations received, the most interesting articles date from 2005. The absolute values trend reveals scarce consideration for the articles developed in 2008, 2009 and 2015. More influence emerges for other years, although far from the citations received by articles published in 2005.

Specifically, three out of five articles bring more than 500 out of 595 citations received in 2005. These top three articles are ranked as presented in Table 1:

These articles seem to represent a reference point for researchers. However, as dating from 2005, they are affected by the time lag occurring between their publication and that of articles (having received significantly lesser number of citations) being published in recent years. In this respect, it is recommended to see the next Table 3, in which these data are standardized by the lag time since their publication.

Additionally, Table 2 provides an overview of the developed articles' trends and number of citations per year. Comparing researchers' efforts to develop articles and the interest in their works confirms the importance of 2005.

These remarks can be easily understood by reading Fig. 6. The graph portrays the differences existing between the number of developed articles and related number of the ones cited from 2005 to 2018. Although the number of papers published in the period 2005 to 2014 is not high, all of them received at least one citation, and in 2011 alone, 4 articles received 28 citations. Furthermore, in some years (2006, 2007, 2012) no papers were published. Importantly, in 2013, a after one-year-break, all seven developed papers received attention by later studies. In contrast, from 2015 on, some articles were not considered as influential and supporting later research. However, the short lag time between the date of their publication and today may play a role in marking their influence.

With reference to the most cited authors and papers, Table 3 discerns the rankings of the most cited articles and related CPY (which stands for "Citation Per Year") for the ten most cited authors. The CPY index presented here was proposed by Massaro and Dumay (2015). Dumay (2014) argues that articles published in recent years "have not had sufficient time to garner citations" (Dumay, 2014, p.22). In our analysis, the most influential authors are M. Redclift and J.C. Hayton, whose works date back to 2005. They also remain the most influential for the CPY. Specifically, as cited 299 times, the research developed by Redclift seems being kind of bible for scholars. The third influential article in CPY rank work was written by Dženopoljac V., Janoševic S. and Bontis N. in the recent 2016. The fourth was developed by Carayannis, Von Zedtwitz in 2005. This data remarks the importance of this year for the topic of IC linked to sustainable development or related

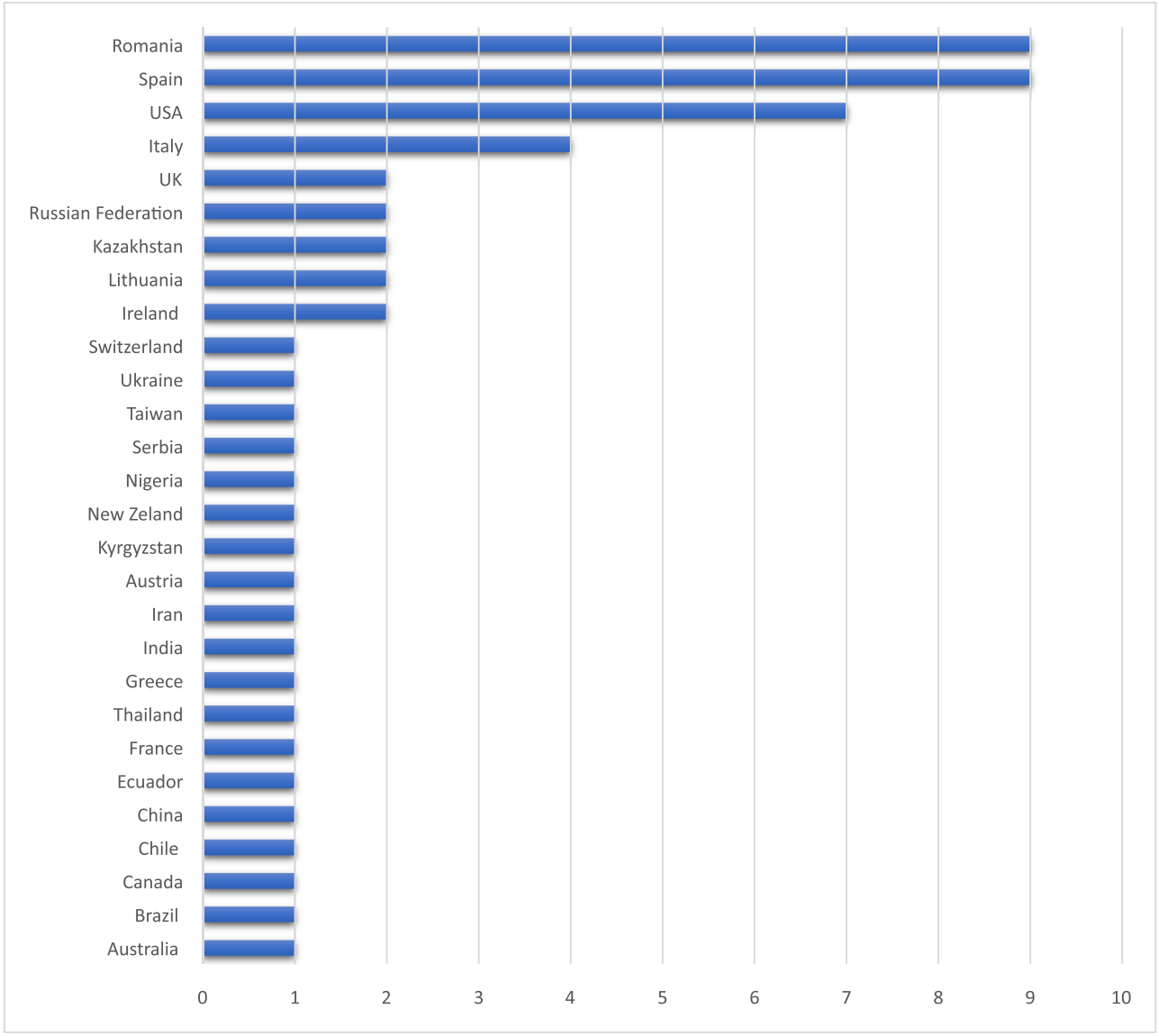

Fig. 3. Geography of the articles by number of items per country.

technology. From the fifth position down, the Citation and CPY values are significantly lower than those mentioned.

These results suggest that prospective authors who want to publish on these topics should "think carefully about how their research is transformational […]" (Dumay, 2014, p.20), and consider not only popular methods and approaches, but confute these by proposing new ones.

3.1.5. Topics and common keywords

Table 4 sets out the Keywords occurrences in 51 selected articles. Keywords are used by authors, editors and publishers to signal important themes in articles. According to Silverman (2013, p. 275), keyword analysis "is a method that allows analysing very large amounts of text without losing touch with focusing on small amounts of the material in considerable depth." In this paper, keywords are classified and analysed through a social network analysis. While Booker et al. (2008, p.240.), argue that "practitioners search for articles based on topics or keywords as they are needed." Similar to the study performed by Ribiere and Walter (2013), keywords were extracted from the articles and a dictionary of terms was created by aggregating similar keywords. In fact, keywords are grouped by their co-occurrence in the same work. Results show 3 clusters. As mentioned in the methodology section, to group together Keywords must occur at least 3 times (threshold). This means that each Keyword is likely tied to others from different clusters, but it does not occur simultaneously, so that the threshold is fulfilled (Fig. 7).

The most recurrent keywords are "Sustainable Development" (10) and "Intellectual Capital" (30) and correspond to 2 out of 3 Keywords we queried on Scopus. As shown in Fig. 7, although they are placed in different clusters, they have links: they occur together but lesser than 3 times. Specifically, "intellectual capital" plays a substantial role in linking green cluster to others. It appears as a word having a wide meaning, with different interpretations as related to the sustainability principles. Interestingly, Keywords regarding sustainability in blues and red clusters are not linked to "Knowledge economy", "knowledge cities" and "intangible assets" from the green cluster. Hence, either there is no link between sustainability (in all its KWs) and these green cluster Keywords, or "intellectual capital" is considered as a broad concept conveying both sustainability and green cluster Keywords meaning.

3.2. Clustering and content analysis

3.2.1. Clustering analysis

The clustering analysis has been conducted through the

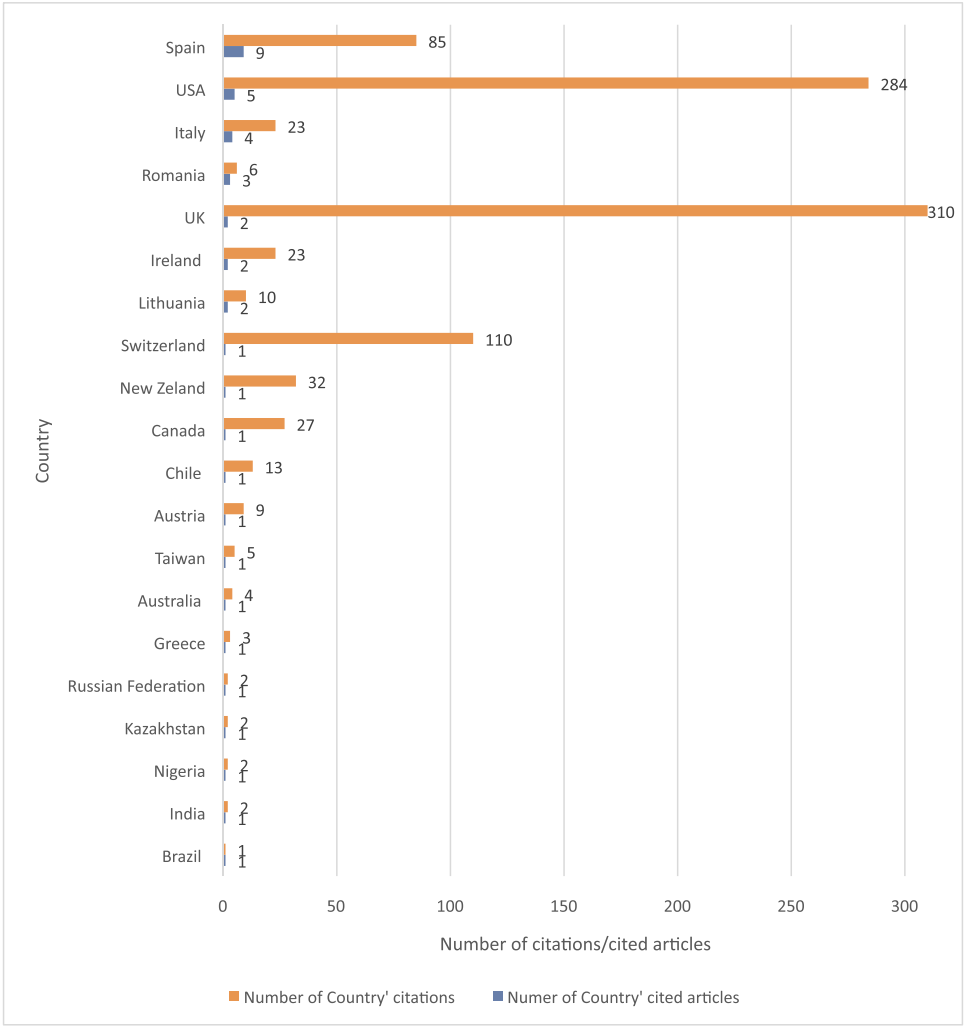

Fig. 4. Geography of the articles by number of citations/cited items per country.

Bibliographic coupling (Kessler, 1963) considering the 51 papers included in the data sample. As explained in the methodological section for the bibliographic coupling, we used documents and sources as units of analysis, and the relatedness is evaluated by considering articles that mainly share the same references (Boyack and Klavans, 2010). The result of this analysis produced 3 clusters and 26 papers (as only papers with 1 citation at least are considered). We considered this clustering to avoid fragmentation of the results as well as the unpacking of the same topic to different areas. The clusters considered bring together those articles that may mark a specific topic/approach (Table 5, Fig. 8).

Fig. 8 shows the clusters considering the strength of the closeness regarding the number of common bibliographies appearing in the article. Therefore, the VOSviewer software cluster technique works after running 10 interactions.

3.2.2. Content analysis

For a more complete understanding of the main emerging research areas, a deep content analysis of the 26 papers is performed. Three researchers proceeded independently with a detailed content analysis by reading all papers with the aim to classify them according to the research area. This process allowed identification of three research areas that synthetize the body of knowledge, and consist of:

- *Research area 1: IC components for achieving Sustainable Development in Private Sector*
- *Research area 2: IC for Sustainable Regional Development in the Knowledge Economy*
- *Research area 3: IC for Sustainable Development in Public Sector*

Although most of the papers belonging to a specific bibliographic cluster respond to the same research area, there is not a perfect matching. There are some exceptions. Therefore, for better representation of the research areas, the 26 papers are re-categorized into the three research areas according to their content and focus, and not only by considering the bibliographic coupling (Table 6).

Research area 1: IC components for Sustainable Development in Private Sector

The first topic area identified provides a general overview about the role of the single IC components for private firms in achieving Sustainable Development. Fourteen papers fall under this topic area category. The papers' content analysis aims to shed light on how academics and practitioners are conceiving IC as a source of sustainable competitive advantage and how its different components (human capital, social capital and structural capital) impact sustainability and performance.

Two main sub research areas emerge: 1) *The role of human, structural and relational capital in generating value for firms, and, 2) The role of IC disclosure for economic, social and environmental sustainability.*

Such distinction into two sub-research areas is necessary given the broader coverage of IC areas and to better understand how specific IC elements (human, social and structural) relate and contribute to SDG. The

Table 1
Highlights of top three cited papers dating back to 2005.

Author (-s)	Title	Cited by	Source	Country (-ies)
Redclift M. (2005)	Sustainable development (1987-2005): An oxymoron comes of age	299	Sustainable Development	UK
Hayton J.C. (2005)	Competing in the new economy: The effect of intellectual capital on corporate entrepreneurship in high-technology new ventures	127	R and D Management	USA, Switzerland
Carayannis E.G., Von Zedtwitz M. (2005)	Architecting gloCal (global-local), real-virtual incubator networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies: Lessons learned and best practices from current development and business incubation practices	110	Technovation	USA

second research area emerging is related to the greater awareness of practitioners and researchers to deal with IC disclosure as a relevant practice for firms.

As for the first sub-research area, the content analysis reveals that the articles focus principally on providing empirical evidence on how IC could impact the attainment of sustainable advantage either by generating new value through the use of human, social and structural capital (Chahal and Bakshi, 2016), or by assisting organisations to improve their innovative capabilities (Nosova et al., 2017). The contribution related to this category are mainly focused on the role of IC in improving performance and achieving sustainable competitive advantages at the firm's level by providing practical experiences of firms operating in high-technology sector, banking sector or bio-economy sector.

Some of the main contributions include: Hayton's (2005) study that discusses the role of IC for new high-tech ventures and argues that IC highly influence the innovative capability of firms as well as corporate entrepreneurship. Consideration of 237 new high tech ventures in the US highlights the relationship between IC components and their entrepreneurial behaviour as a source of sustainable competitive advantage. Reputational and human capital, expressed as the extent of educational diversity and advanced scientific education, influence highly firms' innovation capacity and sustainability (Hayton, 2005). In an SDG perspective, this paper contributes to understanding how IC elements could contribute to achieving Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation (see Table 7)

The study of Pekka-Economou and Hadjidema (2011) analyses the role of IC elements (in particular human capital) in creating knowledge companies that are able to establish sustainable competitive advantage. The banking sector is analysed by Chalal and Bakshi (2016) for examining the value generation through the use of human, structural and relational capital. Considering the data collected from 144 branches of public and private commercial banks in emerging countries (India) the study provides valuable insights into how to improve banks' structural capital by boosting employees' innovation aptitude and positive culture and strengthening information technology.

Other studies that focus on examining the IC role for value creation in the Information Technology (IT) sector are provided by Dzenpoljac et al. (2016) and Nosova et al. (2017). Dzenpoljac et al. (2016) analyse the extent to which IC with its components influences the performance of selected ICTs companies in a transitional country (Serbia). The study entails an important insight related to the fact that in contexts with low levels of research and development expenditures, innovativeness and sources of competitive advantage, the role of IC does not produce the required effects. Furthermore, the study of Nosova et al. (2017) scrutinizes the role of *nano-intellectual capital* in creation of high technologies able to ensure sustainable development of the economy. Meanwhile, the study of López-Gamero et al. (2011) introduces the term '*Sustainable intellectual capital*' as a relevant starting point to handle environmental issues in the general management of firms. Through the analysis of a case study, the paper indicates that sustainable IC supports the accumulation and utilisation of knowledge, introduction of innovations and technology improvements, as well as bolstering the relationship between firms and environment. Another recent study that focuses on the IC role for sustainability on the bio economy sectors is by Vătămănescu et al. (2018). It examines the effects of the online IC conveyed by the digital economy on the consumption patterns through the lens of bio economy. In an SDG perspective this paper contributes to Goal 12: Ensure sustainable consumption and production patterns (see Table 7) and provides practical insights on how IC could contribute to the consumption patterns.

As for the second sub-research area, we found studies that focused on the emergence of human capital as a pillar of corporate social responsibility (Fraguela Formoso, 2013) and the need of reporting

Table 2
Citations trend. Timeframe 2005 - 2018.

Category	Citations received by the papers published each year								
	2005	2006	2007	2008	2009	2010	2011	2012	2013
Citations	595	-	-	13	1	32	28	-	41
Number of papers	5	0	0	1	1	1	4	0	7

Category	Citations received by the papers published each year					Total
	2014	2015	2016	2017	2018	
Citations	31	11	29	21	15	817
Number of papers	3	4	5	6	14	51

standards for shedding new light on the knowledge assets' role in the current dynamics of competitiveness (Liao, et al., 2013), and to achieving an environmental, economic and social equilibrium (Silveira, 2013). Specifically, in the paper of Fraguela Formoso (2013), IC is explored mainly under the perspective of human capital by highlighting the emergence of *emotional capital* that can allow a company to compete by leveraging on the full engagement of employees through their emotions and motivations. The articulated roadmap proposed by Fraguela Formoso (2013) is conceived as a lens for addressing the need for considering renewable energy sources, effective management of waste and pollution, and more responsible environmental sustainability. In an SDG perspective, this paper contributes to Goal 8: Decent work and economic growth (see Table 7), and in particular provides practical insights on creating conditions that allow people to produce quality performances.

Another relevant contribution in this area is provided by the conceptual bridge between the IC and corporate sustainability (CS) literature to investigate how firms mobilize their IC to implement sustainable development in their business practices (Wasiluk, 2013). This discussion is deepened by the contribution of Massaro et al. (2018) that opens the door to a potentially productive way of understanding IC as linked to the development of economic, social, and environmental value. They investigate the relationship between IC and sustainability using practitioners' perspectives and by developing an analysis of comments and practices published in 1,651 blog posts in one of the leading sustainability research sources: CSRwire.com.

Other contributions related to this area are provided by de Leaniz and Del Bosque (2013). They focus on understanding the role played by corporate sustainability in reputation as one of the key components of relational capital. They argue that when firms reveal information regarding social sustainability or economic performance, they influence their competitive advantage. While the study of Oliviera et al. (2010) analyses the disclosure practices among Portuguese firms through sustainability reports as a strategic tool to manage relationships and build a positive image with stakeholders, thus contributing to enhancing their corporate reputation. In an SDG perspective, this paper contributes to understanding how IC elements could contribute to achieving Goal 12: Ensure sustainable consumption and production patterns (see Table 7).

The paper of Liao et al. (2013) focuses on the impact of mandatory adoption of international financial reporting standards on IC disclosure through the empirical evidence of a sample of high tech companies in the UK. In the paper, IC is categorized into a larger spectrum of focal areas, such as process, customer, human, research and development.

As in the majority of the studies in research area 1, all three IC dimensions - human capital, structural and social capital - are considered key elements that influence achieving sustainable competitive advantage. The content analysis of these articles indicates the necessity to understand and recognize the role and value of single IC elements and the need to effectively

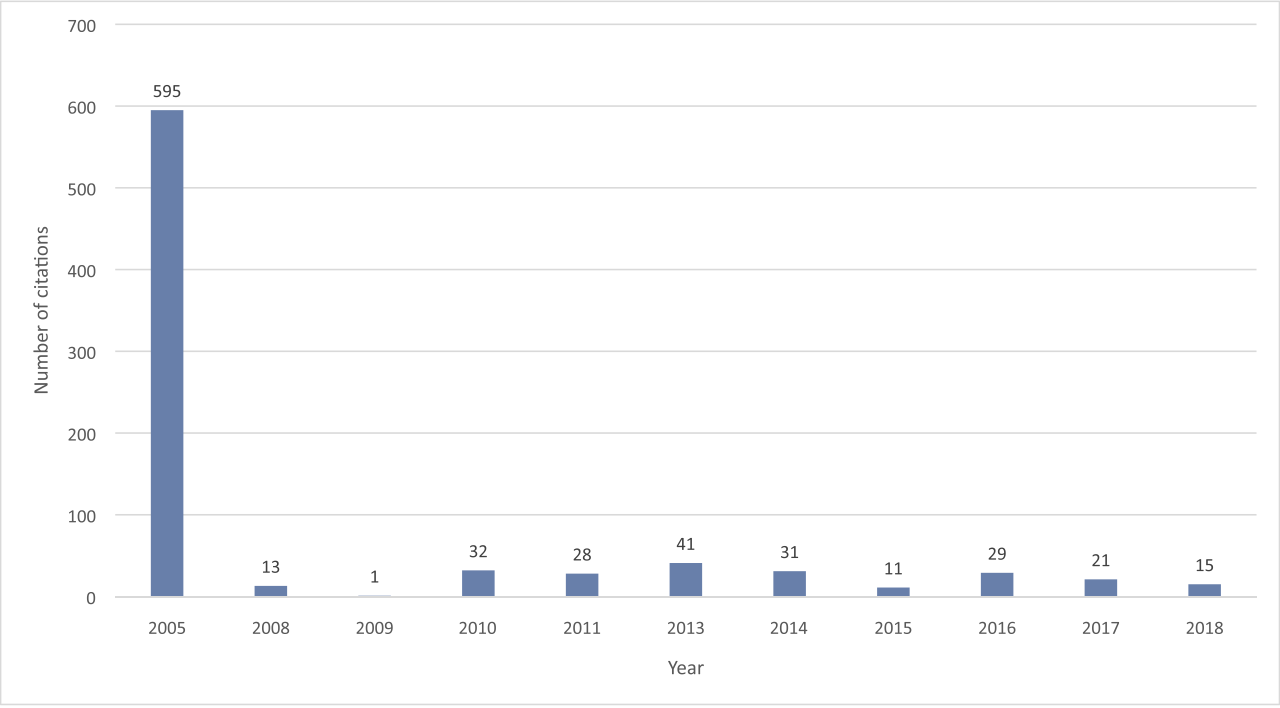

Fig. 5. Number of citations received by articles over the timeframe 2005-2018.

Table 3
Top ten author and article per Citation and Citation per Year (CPY).

Authors	Title	Year	Source title	Cited by	CPY	Ranking CPY
Redclift M.	Sustainable development (1987-2005): An oxymoron comes of age	2005	Sustainable Development	299	21.36	1
Hayton J.C.	Competing in the new economy: The effect of intellectual capital on corporate entrepreneurship in high-technology new ventures	2005	R and D Management	127	9.07	2
Carayannis E.G., Von Zedtwitz M.	Architecting gloCal (global-local), real-virtual incubator networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies: Lessons learned and best practices from current development and business incubation practices	2005	Technovation	110	7.86	4
Gorelick C., Tantawy-Monsou B.	For performance through learning, knowledge management is the critical practice	2005	Learning Organization	43	3.07	8
Oliveira L., Rodrigues L.L., Craig R.	Intellectual capital reporting in sustainability reports	2010	Journal of Intellectual Capital	32	3.56	6
Dženopoljac V., Janoševic S., Bontis N.	Intellectual capital and financial performance in the Serbian ICT industry	2016	Journal of Intellectual Capital	27	9	3
López-Gamero M.D., Zaragoza-Sáez P., Claver-Cortés E., Molina-Azorín J.F.	Sustainable development and intangibles: Building sustainable intellectual capital	2011	Business Strategy and the Environment	25	3.13	7
López-Ruiz V.-R., Alfaro-Navarro J.-L., Nevado-Peña D.	Knowledge-city index construction: An intellectual capital perspective	2014	Expert Systems with Applications	24	4.8	5
Grace A., Butler T.	Beyond knowledge management: Introducing learning management systems	2005	Journal of Cases on Information Technology	16	1.14	10
de Leaniz P.M.G., del Bosque I.R.	Intellectual capital and relational capital: The role of sustainability in developing corporate reputation	2013	Intangible Capital	14	2.33	9

manage these components for sustainable value and advantage. The articles suggest that sustainable growth is a matter of knowledge sharing support, building innovative capability, training, collaboration and technology development and transfer.

Research area 2: IC for Sustainable Regional Development in the Knowledge Economy

The papers included in this second cluster are focused on the comprehension of IC as driver for the sustainable development at level of countries (Navarro et al., 2014), regions (Januškaitè and Užienè, 2018) and cities (López-Ruiz et al., 2014; Navarro et al., 2015; Nevado-Peña et al., 2015). Four papers included in this thematic cluster were written by the same authors, López-Ruiz, Navarro and Nevado-Peña, in the period 2014-2015. At country level, the National IC is identified as an alternative lens on the GDP (Gross Domestic Product) for measuring the wellbeing and wealth of a nation, by considering intangible assets, such as human development, national image, employment conditions, environment, innovation. Moving from this assumption, Navarro et al. (2014) propose a scorecard for measuring national intangible assets composed by six main dimensions of capital, such as human, process, relational or trade, marketing or image, R&D and innovation, social and environmental. In an SDG perspective, this paper contributes to achieving Goal 4: Quality education (see Table 7).

At regional level, scholars confirm that IC is relevant for the full achievement of all the dimensions of a sustainable regional competitiveness, as found by Januškaitè and Užienè (2018) that explore the intersection between IC and sustainable regional competitiveness through a structured literature review and analysis of indexes (World Economic Forum, the Global Sustainable Competitiveness Index, and the Global Green Economy Index). This paper contributes to Goal 17: Partnerships for goals highlighting the need to strengthen cooperation and enhance all stakeholders' engagement for a sustainable competitive advantage (see Table 7).

The contextualisation at city level is predominant in this cluster, mainly regarding its knowledge-intensive characterisation (López-Ruiz et al., 2014). Aimed to support achieving sustainability, better conditions of life and high-quality services, knowledge cities are presented as a favourable locus for enriching the variety of cultural life, increasing people's skills and knowledge, as well as for supporting human intellectual development (López-Ruiz et al., 2014; Yigitcanlar, 2008). The authors focus on IC as an umbrella under which all the dimensions of sustainability and wellbeing are presented in terms of human development, economic structure, trade, image and innovation. They present a complex methodological framework to measure the knowledge cities' growth capacity as conditioned by their knowledge assets and IC. Aiming to provide a measurement of the monetary value associated with the knowledge-driven growth process, the Navarro et al. (2015) study focuses the attention on IC for measuring effects and dynamics of development. They chose a sample of 158 European cities with particular attention on labour market and service variables. The paper demonstrates that being well positioned in terms of sustainable wealth also presents high level of services and labour market dynamics. Such attainments are related to Goal 11: sustainable cities and communities. The paper of Nevado-Peña et al. (2015n) posits a IC based index for assessing the sustainability of European cities. The authors analysed a set of social and environmental efficiency indicators to demonstrate that there is a positive correlation between knowledge and growth rankings. Accordingly, the authors note that in the different growth patterns analysed, environmental sustainability, with specific recycling and waste management policies, is crucial for most of the cities analysed and is promising for the sustainable growth of all the others.

All the articles of this research area highlight that IC plays an important role in achieving sustainable growth mainly focusing on human capital. Specifically, all the papers recall the need for quality education to improve people's lives, to create a more responsible and widespread culture of environmental sustainability, to achieve a sustainable regional competitiveness,

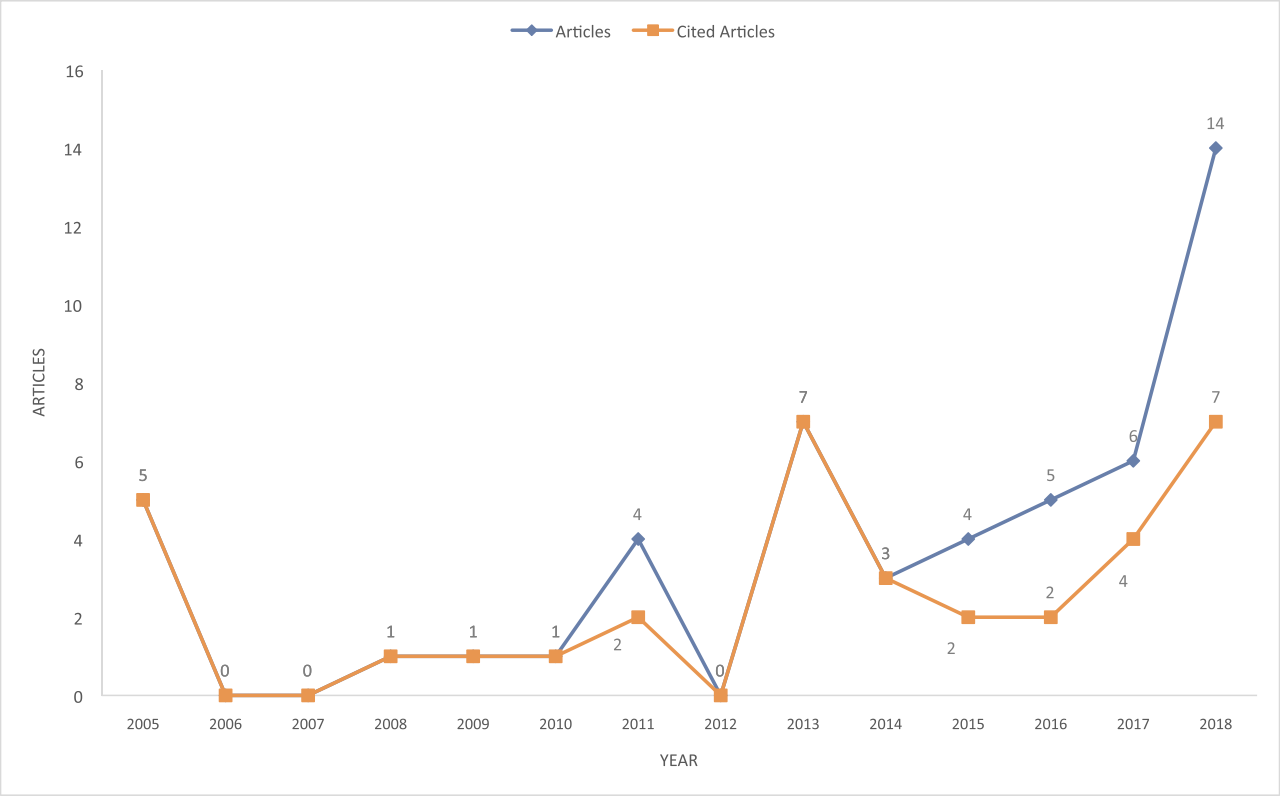

Fig. 6. Number of articles compared to the cited articles over the timeframe 2005-2018.

Table 4
Groups of Keywords occurrence.

	Keywords	Occurrences
Cluster 1 (5 items - red)	Economic Growth	4
	Human Capital	5
	Innovation	5
	Knowledge Management	3
	Sustainable Development	10
Cluster 2 (4 items - blue)	Bio-economy	4
	Relational Capital	3
	Social Capital	3
	Sustainability	5
Cluster 3 (4 items - green)	Intangible assets	4
	Intellectual Capital	30
	Knowledge cities	3
	Knowledge economy	3

at level of environment, society, government, infrastructure, finance and technology, to create connectivity between cities. Moreover, IC is assumed as a feature supporting industrial ecology, as complex combination of environmental efficiency with efficient and sustainable social behaviours.

Research area 3: IC for Sustainable Development in Public Sector

Different trends arise in the adoption of IC as a strategic tool in higher education institutions as Public Universities adopted integrated and sustainability reporting as a voluntary practice. The Brusca et al. (2018) study critically analyses what, why, who and how the new reporting models were implemented to accomplish sustainability in Spanish Universities. Their findings can serve as a learning process for institutions interested in implementing integrated reporting. Furthermore, Secundo et al. (2017) recall in the European policy framework of Smart Specialisation Strategies (RIS3), the need to develop a new conceptual framework based on IC approaches to measure third mission activities of universities actively accomplishing a sustainable and regional development. The framework proposes an overall approach for performance measurement in the Universities to manage third mission performance in terms of goals (continuing education, technology transfer and innovation, and social engagement), impact level (department, university and community), actions (talent attraction, continuing education for entrepreneurship, R&D network development, Intellectual Property & Spin-offs, community engagement and internationalisation) and IC determinants for each action. This paper contributes to Goal 4: Quality education (see Table 7).

Furthermore, the connection of universities' goals with the bio economy is also analysed under an IC perspective by Tiron-Tudor et al. (2018). It highlights the mutual influence of IC disclosures in its ability to foster the development of the bio-economic environment. Until now, many states have developed strategies and policies related to different biotechnology and bio-based industries and products, but increasingly countries are developing strategies that collect all these separate topics under the conceptual umbrella of the bio-economy. Thus, the authors cover a significant gap by approaching the universities' IC disclosure as a strategic means to achieve sustainable development. These papers were published in 2018 when the topic of sustainable development reached its awareness as linked to the IC management coherently with the fourth stage of IC research.

In an SDG perspective, this paper contributes to Goal 4: Quality Education (see Table 7), by discussing universities' role in transferring knowledge.

Another explored public sector context is Health care in Italy, where scholars recently urged research able to unlock the link between sustainable development strategy and IC. Specifically, the paper of Cavicchi and Vagnoni (2017) aims at investigating strategic planning for sustainability within healthcare organisation, and the role that IC plays in Sustainable Development. Results show that the majority of respondents generally adopt sustainable planning in which informal and/or occasional structures or collegial bodies deal with sustainability. The topic is furtherly deepened by Cavicchi (2017) to investigate the role of IC in promoting the Region Emilia-Romagna Health Service's sustainable development program. The author found that, although at

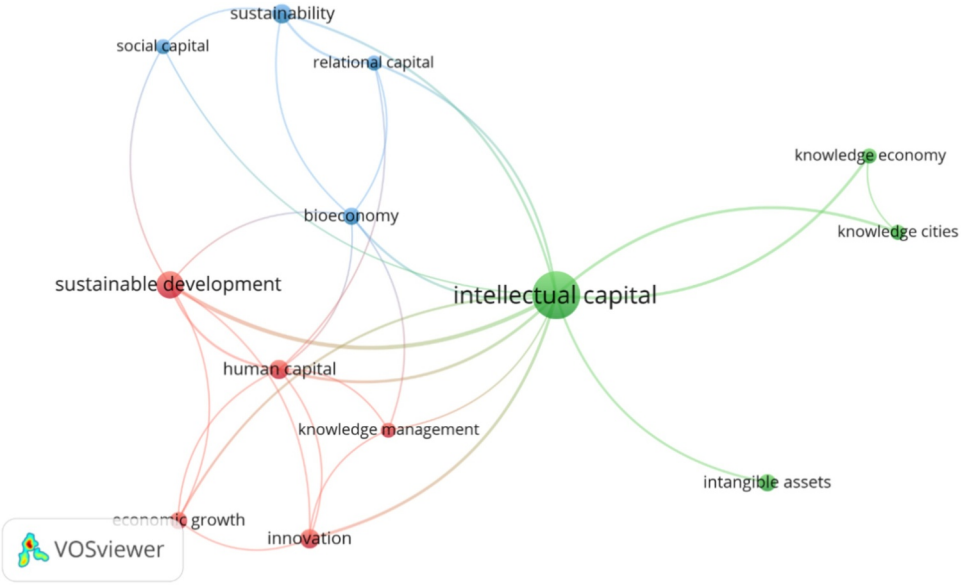

Fig. 7. Keywords' Clusters.

Table 5
Bibliographic coupling clusters.

	Authors	Citations	Title
Cluster 1 (11 items - red)	Arenas T., Lavanderos L. (2008)	13	Intellectual Capital: object or process?
	Chahal H., Bakshi P. (2016)	20	Measurement of Intellectual Capital in the Indian Banking Sector
	Chen I.-S., Chen J.-K. (2013)	7	Present and future: A trend forecasting and ranking of university types for innovative development from an intellectual capital perspective
	de Leaniz P.M.G., del Bosque I.R. (2013)	12	Intellectual capital and relational capital: The role of sustainability in developing corporate reputation
	Dženopoljac V., Janoševic S., Bontis N. (2016)	27	Intellectual capital and financial performance in the Serbian ICT industry
	Hayton J.C. (2005)	127	Competing in the new economy: The effect of intellectual capital on corporate entrepreneurship in high-technology new ventures
	López-Gamero M.D., Zaragoza-Sáez P., Claver-Cortés E., Molina-Azorín J.F. (2011)	25	Sustainable development and intangibles: Building sustainable intellectual capital
	Nosova S.S., Odintsov A.A., Novichkov V.I., Bondarev S.A., Makarenko A.V. (2017)	2	Assessing the role of nano-intellectual capital as a factor
	Oliveira L., Rodrigues L.L., Craig R. (2010)	3	Intellectual capital reporting in sustainability reports
	Pekka-Economou V., Hadjidema S. (2011)	32	Innovative organizational forms that add value to both organizations and community: The case of knowledge management
	Vătămănescu E.-M., Alexandru V.-A., Cristea G., Radu L., Chirica O. (2018)	1	A demand-side perspective of bioeconomy: The influence of online intellectual capital on consumption
Cluster 2 (8 items - green)	Fraguela Formoso J.Á., Carral Couce L., Iglesias Rodríguez G., Sánchez Carricoba M. (2013)	1	The path to excellence: A management strategy based on people [El camino hacia la excelencia: Estrategia empresarial basada en las personas]
	Januškaite V., Užiene L. (2018)	1	Intellectual capital as a factor of sustainable regional competitiveness
	Liao P.C., Chan A.L.-C., Seng J.-L. (2013)	5	Intellectual capital disclosure and accounting standards
	López-Ruiz V.-R., Alfaro-Navarro J.-L., Nevado-Peña D. (2014)	24	Knowledge-city index construction: An intellectual capital perspective
	Navarro J.-L.A., Ruiz V.-R.L., Peña D.N. (2014)	4	Economic growth and intangible capitals: Europe versus Asia
	Navarro J.-L.A., Ruiz V.-R.L., Peña D.N. (2015)	1	An exploratory study of sustainable wealth for European knowledge cities
	Nevado-Peña D., López-Ruiz V.-R., Alfaro-Navarro J.-L. (2015)	10	The effects of environmental and social dimensions of sustainability in response to the economic crisis of European cities
	Silveira M.A. (2013)	1	Strategic management of innovation towards sustainable development of Brazilian electronics industry
Cluster 3 (7 items – light blue)	Brusca I., Labrador M., Larran M. (2018)	2	The challenge of sustainability and integrated reporting at universities: A case study
	Cavicchi C., Vagnoni E. (2017a)	6	Does intellectual capital promote the shift of healthcare organizations towards sustainable development? Evidence from Italy
	Cavicchi C. (2017b)	4	Healthcare sustainability and the role of intellectual capital: Evidence from an Italian Regional Health Service
	Massaro M., Dumay J., Garlatti A., Dal Mas F. (2018)	2	Practitioners' views on intellectual capital and sustainability: From a performance-based to a worth-based perspective
	Secundo G., Elena Perez S., Martinaitis Ž., Leitner K.H. (2017)	9	An Intellectual Capital framework to measure universities' third mission activities
	Tiron-Tudor A., Nistor C.S., Ştefănescu C.A. (2018)	1	The role of universities in consolidating intellectual capital and generating new knowledge for a sustainable bio-economy
	Wasiluk K.L.	10	Beyond eco-efficiency: Understanding CS through the IC practice lens

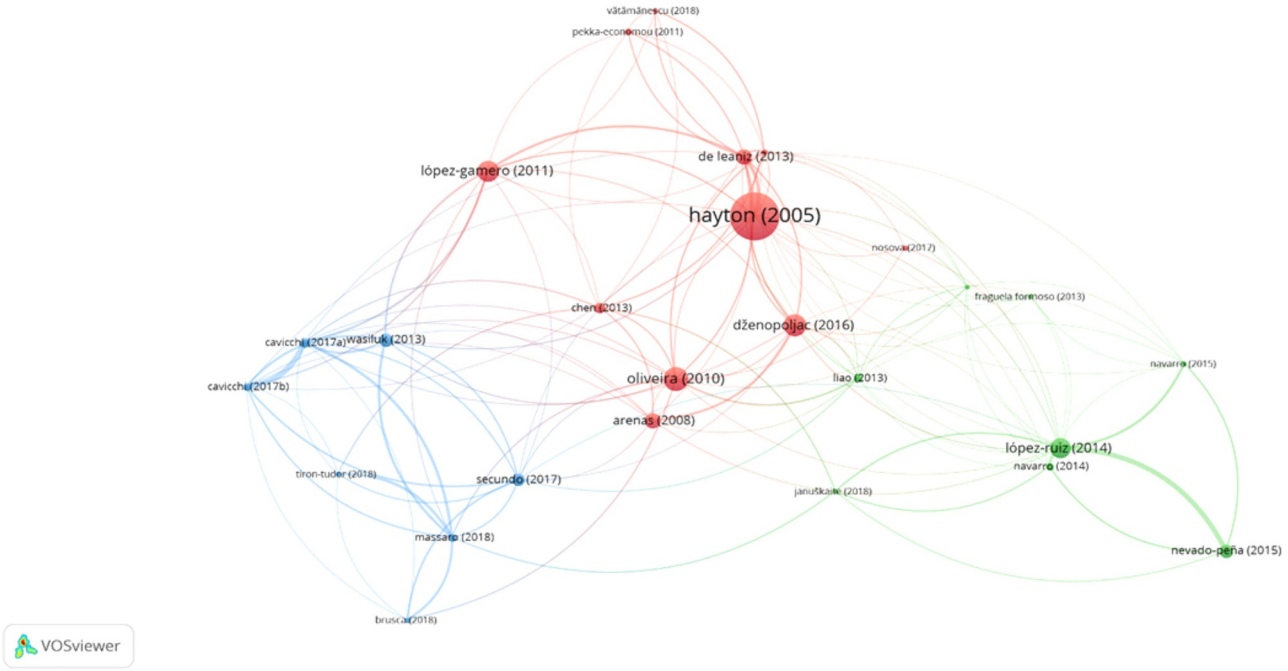

Fig. 8. Clusters grouping items with intersected literature.

strategic level, awareness about the importance of sustainability projects was systematic, the sustainable development culture did not expand at the operative level because of healthcare professionals' lack of involvement in a permanent dialogue for sustainability. In an SDG perspective, this paper contributes to Goal 3: Ensure healthy Lives (see Table 7), and in particular provides practical insights on how technologies could enable sustainability in the healthcare sector.

The articles belonging to Research area 3 suggest that IC is strategic in developing more sustainable higher education at University level, through the definition of indicators for third mission performance measurement or through the development of human and social capital to increase sustainability in healthcare organisations. These thematic perspectives revived the interest of scholars and researchers with empirical contributions just starting in 2017 and 2018 when the importance of the sustainability and sustainable development focus has gained prominence.

4. Discussions and implications

This section aims to answer RQ.3 "What are the research implications in the field of Sustainable Development Goals (SDGs), IC and Technology policies?" by discussing and criticising the main findings. The answer to this question moves toward implications organized into the following sub-sections.

4.1. Research area specialisation: topics, timing and authors

In terms of authors' contribution and focus on the identified areas, many authors have contributed to the debate. Our analysis produced 51 papers focusing on the intersection of Sustainable development and IC. Exploration of the phenomena covers a meaningful timeframe (from 2003, 16 years). In such a considerable period, however, productivity has been fragmented, with some positive picks in 2005, 2013, becoming consistent in 2018. However, the majority of contributions are standalone, dispersed among different journals. This trend is also confirmed by considering the citation results. In fact, the resulting CPY is low (max 21,36). This aspect could be also explained through the limited number of international co-operations among authors, a recognized means to increase the number of citation impacts (Nomaler, et al., 2013). All this does not allow identifying elements of a superstar effect argued by Serenko et al. (2011), in which a small number of authors produced the majority of works. Consistent with the paper of Massaro et al. (2016), the analysis suggests some useful implications regarding low barriers to entry, the authors' related low specialisation on the topics, a still fragmented debate and a consequential need for work systematisation.

4.2. Research area specialisation: Journals

Analysis of the publications' venues has provided an interesting overview of journals that are starting to be more focused on the topic as well as on their influence in terms of citations within a specialized

Table 6
Mapping of papers according to the research areas.

Research areas	Authors
Research area 1: IC components for Sustainable Development in Private sector	Chahal and Bakshi 2016; Nosova et al, 2017; Hayton 2005; Dzenpoljac et al 2016; Pekka-Economou and Hadjidema, 2011; Lopez Gamero et al, 2011; Vatamanescu et al, 2018; Liao et al, 2013; Silveira, 2013; Fraguela Formoso 2013; Wasiluk, 2013; Massaro et al, 2018; Leaniz and Del Bosque 2013; Oliveira et al, 2010.
Research area 2: IC for Sustainable Regional Development in the Knowledge Economy	Navarro et al., 2014; Januškaitė and Užienė, 2018; López-Ruiz et al., 2014; Navarro et al., 2015; Nevado-Peña et al., 2015.
Research area 3: IC for Sustainable Development in Public Sector	Secundo et al, 2017; Cavicchi, 2017; Cavicchi and Vagnoni, 2017; Tiron Tudor et al, 2018; Brusca et al, 2018; Chen and Chen, 2013

Table 7
The link between the Sustainable Development Goals, IC and Technology policies.

Paper	Sustainable Development Goals (SDGs)	IC and Technology policy
Cluster 1		
Arenas T., Lavanderos L. (2008). Intellectual Capital: object or process?	GOAL 9: BUILD RESILIENT INFRASTRUCTURE, promote inclusive and sustainable industrialisation and foster innovation	No reference to technology policy. 'It is thus the network activity and the supporting structure which constitutes IC, and the definition of knowledge in IC happens to locate it in the exchange mode and in the type of configuration in which it makes sense to be exchanged'. Pg. 8
Chahal H., Bakshi P. (2016). Measurement of Intellectual Capital in the Indian Banking Sector	GOAL 12: ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS	No reference to technology policy- Technology is related to the structural capital that is a crucial component of IC. '…..managers can have better understanding of how IC develops and drives performance. … and how they can use intellectual capital as a tool to evaluate organizational performance, which can also enable them to know how value can be created with the help of trained, educated, and creative employees"
Chen I.-S., Chen J.-K. (2013). Present and future: A trend forecasting and ranking of university types for innovative development from an intellectual capital perspective.	GOAL 4: ENSURE INCLUSIVE AND EQUITABLE QUALITY EDUCATION and promote lifelong learning opportunities for all.	No reference to technology policy . The value of technology for IC is in the paper related to mechanisms "…… to acquire and control IC to strengthen innovative ability and to acquire competitive advantages have become critical issues for countries worldwide. Since knowledge, innovation, and IC are highly involved in a university's nature, universities have become critical mechanisms for countries to build up sustainable competitive advantages" (pg. 350)
de Leaniz P.M.G., del Bosque I.R. (2013). Intellectual capital and relational capital: The role of sustainability in developing corporate reputation.	GOAL 12: ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS	No reference to technology policy. "This research allows managers to identify the activities in which companies can devote resources to in order to increase firm's reputation. By knowing these specific economic, social and environmental activities, companies can understand, analyse and make decisions in a better way about its sector and about the stakeholders that assess these initiatives". Pg. 2.
Dženopoljac V., Janoševic S., Bontis N. (2016). Intellectual capital and financial performance in the Serbian ICT industry.	Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	No reference to technology policy. IC as an important potential source of competitive advantage. …….creating value with IC highlights that, unlike tangible resources in a firm whose value erodes with increased use, the value of IC increases with increased use... IC is the main resource for creating extra value in the information age" (pg 19)
Hayton J.C. (2005). Competing in the new economy: The effect of intellectual capital on corporate entrepreneurship in high-technology new ventures	Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	No reference to technology policy. "…… study highlights the complex relationship between aspects of IC and entrepreneurial activities. New ventures seeking to sustain innovation and venturing should attend to the acquisition of the various types of IC" (pg 150).
López-Gamero M.D., Zaragoza-Sáez P., Claver-Cortés E., Molina-Azorín J.F. (2011). Sustainable development and intangibles: Building sustainable intellectual capital	Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Technology policy – related to the structural capital of IC and mainly to the environmental issues "for structural IC, all the firms continuously introduce innovations and improvements in their environmental technology portfolio, which is composed of preventive practices, the creation of an environmental department, the appointment of a management representative and the existence of an environmental manager". pg. 34
Nosova S.S., Odintsov A.A., Novichkov V.I., Bondarev S.A., Makarenko A.V. (2017). Assessing the role of nano-intellectual capital as a factor	Goal 12: Ensure sustainable consumption and production patterns	Technology policy is recalled in the adoption of national programs of clustering for the economic development. As for the IC, it is considered as, "…as a forerunner of the formation of the so-called nano-intellectual capital realized in nano-technologies that substantially change the appearance of innovation activity. It is proved that the creation of high technologies can ensure sustainable development of the economy" (pg 1)
Oliveira L., Rodrigues L.L., Craig R. (2010) Intellectual capital reporting in sustainability reports	Goal 12: Ensure sustainable consumption and production patterns	No reference to technology policy. "firms that adopt higher levels of adherence to the GRI reporting framework, and listed firms, provide a substantial amount of IC information in sustainability reports. There seems strong merit in regulatory institutions working together to develop an integrated report on IC and corporate responsibility matters. ….Sustainability reports appear to be a synergistic and opportune medium for IC disclosures". (pg 590).
Pekka-Economou V., Hadjidema S. (2011). Innovative organizational forms that add value to both organizations and community: The case of knowledge management	Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	No reference to technology policy. IC in the paper is referred to "…. managers need to actively manage their firm's human capital through a variety of human resource practices in

(*continued on next page*)

Table 7 (*continued*)

Paper	Sustainable Development Goals (SDGs)	IC and Technology policy
		order to stimulate its capacity in managing knowledge acquisition, sharing and application. This kind of initiatives could also stimulate creative and innovative thoughts that may eventually lead to better performance and also establish and fully exploit a source of sustainable competitive advantage in the new competitive markets" Pg. 93.
Vătămănescu E.-M., Alexandru V.-A., Cristea G., Radu L., Chirica O. (2018). A demand-side perspective of bioeconomy: The influence of online intellectual capital on consumption	Goal 12: Ensure sustainable consumption and production patterns	Technology policy is in the paper referred to "digitalization – promoted and supported via the Digital Agenda for Europe – contributes both directly and indirectly to the debate on hot societal and economic issues and, implicitly, to the development of the inherent conditions for the formation of online communities based on common interests" (pg. 545- 546)
CLUSTER 2		
Fraguela Formoso, J. Á., Carral Couce, L., Iglesias Rodríguez, G., & Sanchez Carricoba, M. (2013). The path to excellence: A management strategy based on people.	GOAL 8: DECENT WORK AND ECONOMIC GROWTH Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs.	Technology policy is in the paper referred to actions undertaken by companies that "…have to play their part in facing the challenges posed in the Global Compact. Creating policies in terms of research, development, innovation, and ongoing training increases the intellectual capital of the company and the emotional capital of the worker…" (pg. 13).
Januškaitė, V., & Užienė, L. (2018). Intellectual Capital as a Factor of Sustainable Regional Competitiveness..	GOAL 17: PARTNERSHIPS FOR THE GOALS Revitalize the global partnership for sustainable development	Technology policy is in the paper focused on regional competitiveness and the role that "…intellectual capital in regional competitiveness and is even more important concerning sustainable regional competitiveness. It raises an awareness of society about sustainability, defines the legal and institutional environment of a region, expresses the relations between various stakeholders, and together creates the foundation for a sustainable competitive advantage…" (pg.15)
Liao, P. C., Ling-Ching Chan, A., & Seng, J. L. (2013). Intellectual capital disclosure and accounting standards. Industrial management & data systems, 113(8), 1189-1205.	GOAL 8: DECENT WORK AND ECONOMIC GROWTH Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs.	No reference to technology policy. The paper focuses on the disclosures of intellectual capital that "..are closely associated with the international financial reporting standards adoption… to realize the impact of the IFRS adoption on intellectual capital elements so that long-term strategic knowledge assets management may be emphasized for sustainable competitive edge…" (pg. 1189)
López-Ruiz, V. R., Alfaro-Navarro, J. L., & Nevado-Peña, D. (2014). Knowledge-city index construction: An intellectual capital perspective.	GOAL 11: SUSTAINABLE CITIES AND COMMUNITIES There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more.	Technology policy is in the paper referred to the development of knowledge cities as "…the most capable of producing sustainable economic growth. Cities provide the most natural environment in which to look for evidence of the knowledge spillovers so emphasized by the endogenous growth theory. The intellectual capital approach considers the ability to transform knowledge and intangible resources into sustainable long-term wealth. The approach does not only contemplate sustainability and social wellbeing, but also intangible factors such as human development, economic structure, trade, image and innovation…" (pg. 5560)
Navarro, J. L. A., Ruiz, V. R. L., & Peña, D. N. (2014). Economic growth and intangible capitals: Europe versus Asia.	GOAL 4: QUALITY EDUCATION Obtaining a quality education is the foundation to improving people's lives and sustainable development.	No reference to technology policy. IC is in the paper recalled to provide solution at the "…GDP limitations that have prompted the consideration of other measures such as the intellectual capital of nations…" (pg. 263) . "… education is the first of the political safeguards of long-term growth…. Thus, economic growth is divergent, attracting human capital to better position in structural intangible countries…" (pg 272)
Navarro, J. L. A., Ruiz, V. R. L., & Peña, D. N. (2015). An exploratory study of sustainable wealth for European knowledge cities.	GOAL 11: SUSTAINABLE CITIES AND COMMUNITIES There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more.	Technology policy is in the paper referred to the promotion of digitalization and referred to the evidence that "…cities with more sustainable wealth are better positioned in terms of the labour market and that accessibility, tourism and connectivity between cities are key factors for the development of knowledge…" (pg 202)
Nevado-Peña, D., López-Ruiz, V. R., & Alfaro-Navarro, J. L. (2015). The effects of environmental and social dimensions of sustainability in response to the economic crisis of European cities.	GOAL 11: SUSTAINABLE CITIES AND COMMUNITIES There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more.	Technology policy is in the paper referred to the diffusion of safety and environmental technologies. The study also demonstrates as their effective management together with indicators based on social and environmental dimensions of sustainability, and these have allowed us to corroborate that the best-ranked cities for knowledge are also those that have the highest levels of growth in times of crisis ensuring sustainable growth...Therefore, this is the key strategy for sustainable and green growth that will allow European cities to improve the living conditions of its inhabitants and

(*continued on next page*)

Table 7 (*continued*)

Paper	Sustainable Development Goals (SDGs)	IC and Technology policy
		the recovery in economic terms…" (pg. 8266)
Silveira, M. A. (2013). Strategic Management of Innovation Towards Sustainable Development of Brazilian Electronics Industry..	GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE Investments in infrastructure are crucial to achieving sustainable development.	Technology policy in the paper is referred to the BBrazilian experience in the field of solid waste management. since"… as far as Brazil is an emerging economy, it is necessary to develop support mechanisms for the country's companies, especially for those small and medium sized and technology intensive, so that they can develop sustainable competitive advantages that allow them to face the multiple challenges existing in national and international markets…" (pg. 180)
CLUSTER 3		
Brusca, I., Labrador, M., & Larran, M. (2018). The challenge of sustainability and integrated reporting at universities: a case study.	GOAL 4: QUALITY EDUCATION Obtaining a quality education is the foundation to improving people's lives and sustainable development.	No reference to technology and Technology policy. Policy: "The results will be of interest to policy makers and regulators who decide to implement and standardize sustainability or integrated reporting at HEIs, as well as to managers and finance directors at universities that wish to follow these new trends. …The findings can serve as a learning process for institutions interested in implementing integrated reporting" (pg. 348)
Cavicchi, C., & Vagnoni, E. (2017). Does intellectual capital promote the shift of healthcare organizations towards sustainable development? Evidence from Italy.	GOAL 3: ENSURE HEALTHY LIVES and promote well-being for all at all ages	*Technology policy is in the paper referred to* technologies and ICT applications in particular, are considered enablers to sustainability in the healthcare sector…. they can be used in several ways: to assess appropriateness of care services and drug treatments; to improve physicians' decision making by the storage of a patient's entire clinical history; and to increase patients' ability to manage their own diseases with the direct and continuous supervision of healthcare professionals" (pg. 284)
Cavicchi, C. (2017). Healthcare sustainability and the role of intellectual capital: evidence from an Italian regional health service.	GOAL 3: ENSURE HEALTHY LIVES and promote well-being for all at all ages	No reference to technology policy. IC and technology in the paper is focused on the evidence that "hospitals can contribute to sustainability by: reducing the environmental impact of their facilities and transport for staff and patients (where); focusing on prevention and evidence-based care to minimize care necessities (what); changing the general models of care furnishing (how), in particular promoting integration between health and social care, reducing the inappropriate prescribing of drugs, and exploiting technological innovations that can guarantee financial, environmental and social sustainability"
Massaro, M., Dumay, J., Garlatti, A., & Dal Mas, F. (2018). Practitioners' views on intellectual capital and sustainability: From a performance-based to a worth-based perspective.	GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE Investments in infrastructure are crucial to achieving sustainable development.	No reference to technology policy. The paper highlights as "Technology can help companies find new solutions to support accountability. …However, contemporary communication channels are more complex and unstructured… structural capital can contribute by building tools that increase transparency and accountability to support social sustainability. (pg. 9)
Secundo, G., Perez, S. E., Martinaitis, Ž., & Leitner, K. H. (2017). An Intellectual Capital framework to measure universities' third mission activities..	GOAL 4: QUALITY EDUCATION Obtaining a quality education is the foundation to improving people's lives and sustainable development.	No reference to technology policy. IC is in the paper associated to the measurement of the university's third mission that is ", by nature, closely linked to one of the elements of IC, though, as discussed, the three IC components are strictly interrelated to form the IC ecosystem. Thus, continuing education is directly linked with Human Capital while technology transfer and innovation is more related to Organisational Capital, and social engagement with Social Capital" (pg. 234)
Tiron-Tudor, A., Nistor, C. S., & Ştefănescu, C. A. (2018). The Role of Universities in Consolidating Intellectual Capital and Generating New Knowledge for a Sustainable Bio-Economy.	GOAL 4: QUALITY EDUCATION Obtaining a quality education is the foundation to improving people's lives and sustainable development.	No reference to technology policy. IC is in the paper associated to the technology transfer as "A great opportunity for universities is to seek to transfer technology to the private sector, and therefore capture the benefits of commercialization of their innovation and intellectual property rights through many different mechanisms" (pg. 601).
Wasiluk, K. L. (2013). Beyond eco-efficiency: understanding CS through the IC practice lens.	GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE Investments in infrastructure are crucial to achieving sustainable development.	No reference to technology policy. The paper focuses on IC for highlighting as the "Ongoing evolution, with regard to the approach adopted for the management of IC, is also helping to drive organisational change towards more sustainable business models. Each category of IC plays a role with regard to operationalising CS into practice and supporting organisational change" (pg. 102).

community of interested scholars. The geography of papers retrieved from our analysis (see Section 3.2.1) is related to journals focused on IC, Technology Management, and Sustainability. Also, Management journals were included (see Quality - Access to Success. R&D management, Amfiteatru Economic, Business Strategy and the Environment, Technological Forecasting and Social Change). The different types of journals are justified by the peculiarities of the strings adopted for the search.

More specifically, the Journal of Intellectual Capital presents the highest number of papers published (6) while Sustainable Development has the higher number of citations received (299). This trend highlights that the most debated research area developed until now is the one related to IC for sustainable competitive advantage and for value creation at macro (region, cities, etc) and micro level (companies, organisations, institutions, etc.). In terms of higher performances of citations on the number of published papers, some relevant journals register a large number of citations with only 1 paper published (as is the case of *Sustainable Development, R&D Management and Technovation*). In highlighting the coherence between such journals' areas of interest with our topics, this analysis offers useful implications for future studies. From one side, they may provide the root of a major consolidation of the debate in the outstanding journals identified or decide to explore new venues through thematic focuses. In all the cases, scholars and editors' active involvement in a larger dissemination activity, also through co-organisation and sponsorship of thematic tracks within international conferences could be useful for increasing the impact and interest, as pointed by Massaro et al. (2016). Finally, the collective scholarship on achieving SDGs looking to the IC perspective is still in the initial phase, although the first papers about the topic appeared in the 2003. Furthermore, in just a few papers, the concept of ICTs and technology in general as an IC component is now emerging due to the evolution of Digital economy in the last 10 years. This aspect is providing more impetus to the debate about how to afford SDGs and has created a critical mass over the last 3 years. It not only can provide guidance for policy makers and other practitioners, but it has also progressed to being ready for publication in many premier academic journals. The time is right to move beyond a niche field into the mainstream of scholarly debate.

4.3. The role of IC and sustainable development mainly regarding the private sector

Most of the papers in this literature review dealt with the analysis of IC's strategic role in private firms (López-Gamero et al., 2011) and provided empirical evidence related to the effects of IC on sustainable performance (Dzenpoljac et al., 2016; Nosova et al., 2017), reporting and disclosing practices (Oliviera et al., 2010; Liao et al., 2013). Only recently have scholars begun to discuss the potential of IC for achieving sustainable development in all kinds of organisations, also including the public sector and, in particular, higher education and healthcare. This is a context in which sustainability has been discussed as a major challenge to be addressed (United Nations, 2015). Public sector organisations such as hospitals as social service providers can play a relevant role in implementing and assessing tracks towards Sustainable Development (Ball and Bebbington, 2008). They also have relevant responsibilities to support the whole society's shift towards sustainability, as their activity substantially impacts society.

4.4. Relating IC with the SDGs

The linkage between IC and sustainable development is maturing. The content analysis of the 26 papers reveals the main connection and implications of each paper with respect to achieving SGDs. As evinced by Table 7, IC emerges as more relevant for achievement of sustainable growth with clear relevance for goal n. 3, related to the promotion of healthy lives; Goal No. 4, related to development of inclusive and equitable quality education; Goal No. 8, related to the creation of conditions for the high quality work; Goal No. 9, related to the development of resilient infrastructure for sustaining new patterns of industrialisation and fostering innovation; Goal No. 11, related to the development of sustainable cities and communities to make services, energy, housing, and transportation accessible; Goal No. 12, related to development of sustainable consumption processes and behaviours and sustainable production patterns, and Goal No. 17, related to the need for developing partnerships as relational capital useful for the sustainable development. This analysis allows identifying the need to consolidate the areas already identified at the intersection of IC, in all its components, and SDGs, through conceptual and empirical studies, as well as investigating the remaining SGDs to assure the full coverage of all the dimensions of sustainability and to provide broader implications for development of technology policies.

4.5. Exploring technological domains for a sustainable development based on IC lens

The analysis conducted has allowed understanding how in the actual digital and knowledge based economy, characterized by the pervasiveness of ICT and advanced technologies, IC is a useful lens for exploiting their potential domains of applications as well as for capitalising their value under the perspectives of human, relational, and structural assets. Despite this, the full comprehension of the antecedents and consequences of their implementation is limited in the dimensions of disclosure and reporting of value creation. This is a common trend characterising ICTs and the more recent technologies of Big Data, but it interests in the same way also other technological domains.

The existing literature provides us with some insights regarding the role of structural capital for sustainability, but no studies were found in this SLR that link IC, ICT and sustainability. Since ICT is considered to have a vital role to play for sustainable development, detailed and specific studies are necessary for better understanding its role. An examination of the link and interaction between new technology areas, human development and interaction has not been fully explored (Gouvea et al., 2018). Further research is needed to better grasp the role of technologies (as a component of structural capital) in enabling achieving SGD goals. It has been argued that ICT can accelerate and scale sustainable development by enabling access to information and services, increased connectivity between individuals, organisations, and networking and efficiency from improved productivity and resource efficiency (Nam, 2015). ICTs arise as technological domain of interest for future studies as they enable the development of qualitative human, social and structural capital.

In the meantime, the analysis of the structural capital could concern the exploration of Key Enabling Technologies, as a means for smart and sustainable growth of companies and regions. Impacting on the innovativeness of existing industrial domains and operating at the foundation of new ones (McCann and Ortega-Argiles, 2013; Romano et al., 2014), such technologies are identified in cross-sectorial and knowledge intensive families of technologies (e.g., nanotechnology, micro and nano-electronics, advanced materials, biotechnology and photonics) able to support private organisations and public institutions in the full achievement of several of SGDs. Finally, environmental sustainability arises in the literature analysed as one of the most common and relevant dimensions of IC impact on sustainable development (Januškaitė and Užienė, 2018; Navarro et al., 2014; López-Ruiz, et al., 2014; Nevado-Peña, et al., 2015). Moreover, its inclusion in the current debate is only ancillary to the conception and execution of sustainable development strategies by companies and public authorities. Thus, an implication that emerges for policy-makers is related to the creation of Technology ecosystems, in the aim to foster and sustain inclusive, equitable and sustainable economic development and growth agendas and strategies (Gouvea et al., 2018).

Table 8
Future agenda: sustainable development, intellectual capital and technology implications.

Sustainable Development Goals (SDGs)	IC determinants	Managerial Practices	Technology Policy for Sustainable development	Future agenda: Research questions
GOAL 4: QUALITY EDUCATION Obtaining a quality education is the foundation to improving people's lives and sustainable development.	*Human capital* *Structural capital* *Social Capital*	Education as the main safeguard of a long term growth; Universities education strengthens the innovative ability and the acquisition of competitive advantages; Manage human capital to fully exploit the sources of sustainable competitive advantage;	Strategic aim: Building capacities through the investments in ICTs and digital platforms for the sustainable innovation in learning;Processes: ● Launching of pivotal initiatives and incentives for the development of digital platform to support the sharing and the diffusion of a "sustainability culture". ● Ensuring that new technologies are used to train all sectors of society in systems approaches to global sustainability.	How ICTs and digital platforms can allow the creation of innovative learning path for the human capital creation according to the sustainability perspective? Which digital platforms could support the diffusion and the engagement of students for creating a more "sustainable society"?
GOAL 8: DECENT WORK AND ECONOMIC GROWTH Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs.	*Structural capital* *Social Capital*	Creating emotional capital of workers for improving companies' performances	Strategic aim: Creating new favorable environments and tools for human capital enhancement.Processes: ● Embracing collaborative digital platforms as enabler for knowledge sharing, community building and social inclusions. ● Promoting the transfer of technologies from 'developed' to 'less developed' countries	How ICTs and digital platforms can enhance workers' engagement and create emotional capital toward social sustainability? Which digital platforms could enable the sharing of the "sustainability issues" among the local community?
GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE Investments in infrastructure are crucial to achieving sustainable development.	*Social Capital* *Human Capital*	Creation of organizational ecosystems for social, economic and environmental balance; Accumulate, integrate, and creatively harvesting knowledge to sustain innovation; Reputational capital is a significant predictor innovation and venturing activity; Diverse human capital implies diverse sources of social capital that enhances collective creativity.	Strategic aim: Enhancing the competitiveness and the innovation performances of companies. Processes: Promoting of programs and investments in ICTs, Digital Technologies and collaborative tools supporting the creation of organizational ecosystems and network of SMEs	How ICTS to promote the creation of organizational ecosystems for the sustainable competitiveness of high-tech SMEs in emerging economies? How technologies could enhance Innovation and Improve Infrastructure for the achievement of sustainable development?
GOAL 11: SUSTAINABLE CITIES AND COMMUNITIES There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more.	*Structural Capital* *Social Capital*	Accessibility, tourism and connectivity between cities are driver of sustainable development Mechanisms for transforming knowledge and intangible resources into long term wealth Environmental and social sustainability to improve the living conditions of cities' inhabitants	Strategic aim: Enhancing infrastructure (such as logistics infrastructure, innovation platforms, transports, connectivity) to transfer, foster and share innovations for sustainability. Processes: Stimulating public and private organizations to launch pivotal initiatives and incentives in the field of ICTs, Big Data, and Artificial Intelligence for value creation in traditional and innovative industries; promotinginvestments in green technologies, waste management and circular economy	How to optimize technologies for connectivity, transport and logistics for the achievement of environmental sustainability? How ICTs, Big Data and Artificial Intelligence can support the process of long-term value creation in the context of knowledge cities? How green technologies can support the creation of a more efficient management of cities' waste and promote virtuous processes of circular economy?
GOAL12: RESPONSIBLE PRODUCTION and CONSUMPTION Ensure sustainable consumption and production patterns	*Human capital* *Structural capital* *Social capital*	Use the 3 components of IC (human, social and structural) as a tool to create value with the help of trained, educated, and creative employees Better understanding of how intellectual capital develops and drives performance Disclosing sustainability information about the leads toward creation of reputational capital and sustainable competitive advantage IC is a forerunner for the creation of high technologies that ensure sustainable development of the economy	Strategic aim: Harnessing the potentialities of digitalization, ICT, big data, online collaborative platforms, nano-technologies to achieve sustainable innovation. Processes: Embracing campaigns and initiatives of sensitization and awareness creation on the benefits of green behavior and new sustainable consumption and production models.	How new emerging technologies can enable access, connectivity and efficiency for the innovation processes supporting (social, economic and environmental) sustainability?
GOAL 17: PARTNERSHIPS FOR THE GOALS Revitalize the global partnership for sustainable development	*Structural Capital* *Social Capital*	Media and government efficiency to lead social and environmental sustainability	Strategic aim: Building a culture of the collaboration and networking for development. Processes: formulating and executing interventions by public and private organizations for enhancing the adoption of ICTs and media for higher education.	How digital technologies can support the creation of transnational partnership for environmental sustainability?

5. Technology policy and IC for sustainable development: a future research agenda

The analysis conducted in terms of thematic clustering, content analysis and citations' impact allows deriving some useful insights regarding what is provided by the literature so far in terms of technology policy. Specifically, the focus of our SLR on IC, technology and SDGs suggests the opportunity to define a policy mix as the combination of different policy instruments and strategic actions for sustainable development of technology and innovation (Rogge and Reichardt, 2016; Lehmann, 2012).

As reported in Table 7, we found some references regarding technology policy in 10/26 papers. Therefore, such insight could be a starting point for defining the state of the art of literature regarding IC, SDG and technology policy, as well as for defining the most relevant areas where future research could be concentrated. This is especially true if we consider that the phenomenon is still in its infancy.

Table 8 presents some of the main technology policies already reported in the existing literature. Although it is still in its early stages, our research reveals that some contributions related to technology polices are being highlighted. The technology polices mainly regard:

- Building capacities through investments in ICTs and digital platforms for sustainable innovation in learning.
- Developing digital platforms to support technology transfer capacities and dissemination of a "sustainability culture."
- Embracing collaborative digital platforms to enable knowledge sharing, community building and social inclusions.
- Harnessing the potentialities of digitalisation, ICT, big data, online collaborative platforms, nano-technologies to achieve sustainable innovation.

Promote networking and collaboration among different stakeholders. In addition, a future research agenda is depicted (see Table 8) considering the SDGs emerging from research, IC determinants, managerial practices highlighted in the paper analysed, and finally, the technology role for this important achievement at global level. Accordingly, evidence for the development of technology policies based on IC has been identified with the aim to cover areas that are still unexplored or under researched and to derive roots for research and policy makers' future agendas. In achieving a sustainable goal, it is compulsory to consider some critical features to make them coherent with the requirements of a sustainability policy mix as identified by Rogge and Reichardt (2016) in terms of strategic goal and processes. Additionally, in all of them, respect has been assured for their model's third element consisting of characteristics of consistency, coherence, credibility, and comprehensiveness. By focusing on IC and technologies as drivers for achieving SDGs, these policies will impact a global community of actors, they must be able to shape countries' boundaries and allow achieving ambitious goals (Stafford-Smith, et al., 2017; Edmondson, et al., 2018). Since the SLR contribution request is to provide inspiration for future studies, the table also defines for each SDG the main IC components, the associated managerial practice, technology policy and research questions.

The emerging research areas call for more specific contributions by academics for understanding:

How can ICTs and digital platforms allow the creation of innovative learning paths for human capital creation according to the sustainability perspective? Which digital platforms could support dissemination and student engagement for creating a more "sustainable society"? Which digital platforms could enable sharing "sustainability issues" among the local community? How could technologies enhance Innovation and Improving Infrastructure for achieving sustainable development?, etc. Specifically, Table 8 lists the main emerging areas regarding the specific SDG resulting from our study. Finally, we think that since the analysis of IC and SDGs lies at the intersection between IC management literature and the literature about the different SDGs, knowledge development about the role of IC for the SDGs could be framed in different journals. We think that the 17 SDGs goals could have a knowledge development process in several journals where the topic is analysed. The common point to the several journals should be analysis of the phenomenon through the IC lens.

6. Conclusion and limitations

In this study's conclusions, it is important to recall the paper's aim of understanding the state of the art in the literature at the intersection of IC and SDGs, with a specific focus on technology policies and its future research due to the debate's infancy phase.

Accordingly, the paper offered an outline of past and present debate through a structured review of the papers published in journals from 2003 through 2018.

As Massaro et al. (2016) argued, an SLR "is not the end of the road, but the beginning of new journeys." Despite the positive relationship between IC and sustainability, full comprehension of their linkage and intrinsic meaning for the development of technology policies calls for a deeper understanding, mainly regarding the implications in terms of technology policies. Therefore, this paper calls for future developments more focused on the specific theme with reference to technology policy.

Specifically, their intersection discloses several areas of in-depth study related to the need of overcoming the fragmented comprehension of how the adoption of IC in the debate on sustainable development can support the development of technology policies aligned with the SDGs of United Nations.

Although the number of papers published on IC and SDGs in the period 2003-2018 reached a consistent volume, the analysis of their meaning, dynamics and implementation is still dominated by unrelated research, with a wide range of thematic specialisations shaped by value creation at micro and macro level, regional development in the context of the knowledge economy, sustainable development in public and private sector. Trends observed in terms of authors' productivity, impact of their research in terms of citations, and their geographical areas depicts a scientific community that is still dispersed, with limited collaborations. Moreover, the number of authors really focused on the topics with outstanding performances is still limited. In all cases, it is far from the superstar effect (Serenko, et al., 2011). Despite this, the trend of renewed interest during 2018 is promising.

As for the publications' venues, a coherent correspondence has been identified between the journals' thematic specialisation and the higher number of publications and scientific contributions published, although their number is limited to four. Meanwhile, the remaining other papers were dispersed and located with a single contribution in other journals. All this highlights the need for consolidating the relevance of the issues of IC and Sustainable Development in their projection toward development of technology polices in terms of co-authorships among foreign authors, new contexts of explorations, and journals with thematic specialisations.

Content analysis in the paper has allowed identifying three main thematic clusters as main areas of specialisation of the scientific debate, with related sub areas. Despite the absence of an explicit specialisation on the topic, three main areas arise around the following thematic clusters: *1) IC components for achieving Sustainable Development in Private Sector; 2) IC for Sustainable Regional Development in the Knowledge Economy; and finally 3) IC for Sustainable Development in Public Sector.*

The analysis of papers included in these three areas allowed outlining areas of specialisation in terms of conceptual models, reviews of the literature, interpretative models, metrics, and impacts on private companies and public organisations. Implications in terms of technology policies have been highlighted at the intersection of the research between IC and Sustainable Development. The critical reading of the papers included in the thematic clusters allowed identifying, regarding some specific SDGs, the dimensions of IC impacting and the managerial

practice associated with the most relevant technologies and related research questions for developing the future agenda. In enriching our SLRs' evidence, the table represents the element of major value for developing studies on technology policies.

The study's limitations can be identified in the nature of the papers included and the exclusion of papers published in book chapters and conference proceedings. Because of the topic's novelty, some research is just in its initial phase and presented as preliminary in the conference proceedings. With the same logic, we cannot exclude that valuable research has been published in papers not included into Scopus, despite its recognized value and dissemination in the international scientific community. Secondly, the validity of the evidence collected is limited to the timeframe considered. Third, as argued by Massaro et al. (2016), a SLR is only the beginning of a new journey; its value is more in providing inspiration to the community of scholars and researchers than in the state of the art.

Another limitation is related to the selection bias that arises when considering the scope of the topic. Although we tried to limit such bias (as specified in the methodology section), some risk remains related to the exclusion of relevant articles from further analysis.

Accordingly, we hope that despite its limitations, this work has offered good comprehension of the issue of IC and sustainable development and that it can contribute to providing inspiration for the advancement of research in technology policies.

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