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Intellectual capital-based research impact management: a strategic approach to increase regional intellectual capital

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Abstract

Purpose – Entrepreneurial universities, through their intellectual capital (IC), can promote the development of a third mission, which involves collaborating with business and societal organizations to create value. Joint research projects are undertaken within entrepreneurial universities leveraging their IC. These generate value for both the academic community and the territory as they generate impact, in terms of regional IC. At the micro level, scientists in the principal investigator (PI) role are influential actors in generating impact and IC that is beneficial for all joint project stakeholders. The purpose of the paper is to address the existing gap in entrepreneurial university literature concerning the impact generation process.

Design/methodology/approach – The paper represents a theoretical contribution adopting a deductive approach.

Findings – This paper proposes a novel approach to support PIs in entrepreneurial universities in the process of managing innovative initiatives toward IC impact generation. First, we present the IC-based Research Impact Tool (ICRIT) to guide PIs acting as explorative entrepreneurs; then we propose an IC-based Research Impact Report (ICRIR) including some key performance indicators (KPIs) to evaluate impact and IC.

Research limitations/implications – The theoretical approach proposed could be developed further. This could be furthered through more empirical studies using initially, for example, comparative cross-country case study research.

Originality/value – The paper sheds new light on the importance of the final impact generated by research initiatives, focusing on the crucial role played by PIs and promoting the adoption of an IC-based strategic approach, to maximize the final impact of projects, in terms of regional IC.

Keywords Intellectual capital, Research evaluation, Impact reporting, Entrepreneurial university, Principal investigator, Impact, Regions

Paper type Conceptual paper

1. Introduction

Intellectual capital (IC) is an essential element for value creation in organizations. The concept of IC was initially analyzed in for-profit enterprises and later extended to public and non-profit

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organizations (Benevene and Cortini, 2010; Bueno Campos *et al.*, 2006) with some interest in the management of universities, as their main inputs and outputs are intangible assets and knowledge (Chau *et al.*, 2017; Mariani *et al.*, 2018; Secundo *et al.*, 2015, 2017a, b, 2018). In response to social, economic, cultural and political changes, European universities are moving towards the adoption of the emerging entrepreneurial university model (Menter, 2024; Thomas *et al.*, 2023).

As economies evolve, there is a need to create and maintain networks of knowledge, to combine knowledge theory and business practice, to strengthen the cooperation between two different environments, research and business, in order to obtain economic and social outputs, outcomes and impacts (Del Giudice and Maggioni, 2014). Entrepreneurial universities have responded to challenges and demands by becoming increasing engaged in third mission activities, collaborating with industry and in the technology transfer process (D'este and Perkmann, 2011; Nicotra *et al.*, 2021). Part of their mission of an entrepreneurial university as an anchor institution is to promote such a cooperation in the network of knowledge within and beyond the territory they inhabit (Zaharia and Gibert, 2005). Within regions, entrepreneurial universities can contribute to the development of heterogeneous networks and can facilitate the exchange of tacit knowledge, the formation of communities of practice and the greater access to advanced human resources (Lave and Wenger, 1991). As Trequattrini *et al.* (2018) argue, entrepreneurial universities are a critical regional actor in developing and enhancing intellectual property.

As national and European funding programmes increasingly require collaborative arrangements between local and regional businesses and entrepreneurial universities through more mission orientated initiatives, they provide a basis to generate regional IC. Such joint collaborative projects can have direct impact on businesses and indirect knowledge spillover effects (see Secundo *et al.*, 2021; Bamford *et al.*, 2023). For the purposes of this paper, we define impact in broad terms that considers the persistence in time and scope of the short-term results. Impact can be measured in terms of IC creation (see Trequattrini *et al.*, 2018). Against this background, the aim of our paper is to address the gap in the entrepreneurial university literature, proposing a novel Intellectual Capital-based Research Impact Management (ICRIM) approach. This is a way both to manage and measure the impact of research projects developed by entrepreneurial university jointly with other organizations, in terms of IC management and measuring. In the process of ICRIM, principal investigators (PIs) play a strategic value creation role in the development and exploitation of intellectual property and act as boundary spanners between businesses and entrepreneurial universities (see Mangematin *et al.*, 2014). Moreover, as Cunningham *et al.* (2016a, b, p. 779) argue that PIs "are the linchpins of knowledge transformation through articulation of research programmes . . ." and as well shaping new scientific avenues the role also involves extensive engagement with external businesses throughout a funded project's lifecycle (Boehm and Hogan, 2014; Feeney and Welch, 2014). A scientist takes on the role through securing competitive funding to lead a research programme or activity, and the PI is responsible for all aspects of project management and delivery (Cunningham *et al.*, 2016b). Part of the PI role is to realize project impacts in the main focusing on realizing scientific, technological, market and economic impacts (see Cunningham *et al.*, 2020).

To support the realization of entrepreneurial university's third mission objectives, at the micro level, it is necessary for scientists in the PI role to develop an entrepreneurial orientation (see Romano *et al.*, 2017; Casati and Genet, 2014). Such a mindset enables PI to capitalize IC developed in universities, addressing their activities to the creation of spin-off companies or other appropriate technology transfer mechanisms, thus changing their project administrator state of mind. Their actions should be considered in a direct way of transferring scientific knowledge to markets and contributing to economic growth. In their role, PI can influence and shape knowledge creation and exploitation of public research (see Cunningham *et al.*, 2016a, b, 2022). One of the functional activities in the PI role is to coordinate the network of knowledge in order to spur innovation and entrepreneurship as knowledge brokers (Kidwell, 2013) and to acquire an ability to manage their PI role identity through learning and role violation (O'Kane *et al.*, 2020).

Starting from these considerations, we deal with PIs as explorative entrepreneurs (Romano *et al.*, 2014b). They are able to combine knowledge theory and business practice, to coordinate the network of knowledge initiatives. One objective of their research activities is to generate an impact on society at large beyond scientific knowledge (Carl, 2020). The realization of this goal depends on the scientific competences of the PIs and the researchers but, above all, on their capability to make innovations attractive for the market, to influence the broader culture of entrepreneurship in the context they work, to facilitate the creation of new innovative firms (Mangematin *et al.*, 2014). In particular, the final impacts triggered by a PI-led funded project depend on a complex impact management process that includes impact forecast (often required by funding bodies), impact generation and impact reporting (Smit and Hessels, 2021). The PI is responsible for the impact generated and should therefore be provided the tools to face the above-mentioned process along with developing an entrepreneurial mindset.

The purpose of this paper is to propose a novel IC-based Research Impact Management (ICRIM) approach to support PIs in the process of managing and measuring IC impact generation.

In the ICRIM approach, we propose an IC-based Research Impact Tool (ICRIT) and a comprehensive IC-based Research Impact Report (ICRIR) to support the research impact management process.

2. Literature background

2.1 The role of entrepreneurial university in economic development

The model of entrepreneurial university has evolved coherently with the growing recognition of knowledge as an intangible factor determining economic growth and the related rising of new conceptions of knowledge production and innovation process (see Sánchez-Barrioluengo *et al.*, 2019; Rådberg and Löfsten, 2024). Entrepreneurial universities combine teaching, research and contributing to the economy particularly in the local region (Etzkowitz *et al.*, 2000)). The engagement of universities in third mission activities started with the establishment industry–university collaborations and the creation of joint research projects between public and private sectors. Entrepreneurial universities responded in particular, the establishment of technology transfer offices (TTOs), academic incubator and the implementation of patent policies were led by the need for to regulate the exploitation of their intellectual property (see, Nowotny *et al.*, 2003, Romano *et al.*, 2014b.

In pursuing the third mission and growing its intellectual property portfolio, the entrepreneurial university develops a complex system of relationships, a network of knowledge with other research centers, institutions and companies that share the mission of enhancing the competitiveness of the region through research, innovation, technology transfer and dissemination of a culture of quality and specialized training (Ricci *et al.*, 2019; Feola *et al.*, 2021). The role of entrepreneurial university is to establish a network of knowledge with other universities, governments, customers or other actors, and it is an organizational response to the complexity or uncertainty of technology and market (Tidd and Bessant, 2020; Fuster *et al.*, 2019). As a knowledge network, the entrepreneurial university is a learning organization and needs to be intrapreneurial, leveraging the ability of academics to orchestratie available resources and utilize critical knowledge to foster innovation and generate value within the boundaries of the academic environment (Klofsten *et al.*, 2024; Flores *et al.*, 2024).

2.2 Intellectual capital in entrepreneurial university

The role of IC in universities is critical, as universities are the focus of intangible activities strictly related to develop, transmit knowledge and commercialize it (Silvestri and Veltri, 2011; Stewart, 1997; Fazlagic, 2005; Leitner, 2004; Paloma Sánchez *et al.*, 2009; Ramírez Córcoles *et al.*, 2011) leveraging collaborative partnerships that involve actors on government, university and industry sides (Carayannis *et al.*, 2014). IC expresses all knowledge, information, intellectual property and experience possessed by an organization (Stewart, 1997), and represents one of the most important elements for the management and assessment of the internal and external organizational processes. The broad concept of IC has been often split into different categories, commonly defined as human, relational and structural capital (Ramírez Córcoles *et al.*, 2011; Cañibano and Sanchez, 2008). Within the burgeoning literature on entrepreneurial universities, IC has not been the focus of much empirical and research attention (Compagnucci and Spigarelli, 2020; Forliano *et al.*, 2021).

Human capital is a fundamental part of university IC, it represents the knowledge, skills and ability of all the individual who offer their contribution within the organization, such as faculty, researchers, managers, professional services administrative staff and students in general (Ramírez Córcoles *et al.*, 2011). In particular, the IC of professors and researchers is represented by their teaching and research competencies along with domain specific know-how. The importance of human capital also lies in its ability to shape and drive entrepreneurship. Generally, the structural capital refers to the organizational culture, routines, products and capabilities, so it is the backbone that supports IC within the organization; relational capital is linked to the building of relationships between a specific organization and its environment (Silvestri and Veltri, 2011) that provides a knowledge increase for the organization; it is represented by the interactions that universities have with external stakeholders, always in a third mission perspective.

In the literature, university-related IC has been used to identify structural and personal strengths and weaknesses, reveal the current state of the realization of the university's third mission and can be used as an evaluation tool. Several papers have dealt with the assessment of universities' IC (Silvestri and Veltri, 2011; Ramírez Córcoles *et al.*, 2011) and investigated the relationship existing between the IC of the universities and their performance (Bueno *et al.*, 2014). For example, Secundo *et al.* (2015) suggest analyzing how IC can promote the development of the third mission within the university. Furthermore, Secundo *et al.* (2015) adopt an IC framework to identify appropriate performance measures of third mission activities. Later, Secundo *et al.* (2017b) propose and test an IC-based model to monitor and manage the third mission and research and teaching activities in an integrated way.

In particular, some measures of universities' third mission activities related to IC framework include explicit and tacit knowledge of researchers (Ramírez *et al.*, 2017), publications, licenses, patents, copyrights, fulfilment of research projects (Ramirez *et al.*, 2007), talent attraction, entrepreneurial education outputs, knowledge diffusion, infrastructure enhancement and intellectual property and spin-off. A broader evaluation of IC can be performed at ecosystem level (Chin *et al.*, 2023) as well as at a regional level. Regional IC, from a knowledge perspective, represents the set of knowledge asset possessed by a geographical area that fosters value generation in that area (Schiuma *et al.*, 2008). Research projects driven by PIs have the potential to impact on regional IC (see Cunningham and Menter, 2021; Siegel *et al.*, 2023).

2.3 PIs as explorative entrepreneurs in an entrepreneurial university

There has been a growing body of literature that has focused on academic PIs roles, responsibilities and attitude, developing some categorizations (see Cunningham *et al.*, 2014, 2015, 2022; O'Kane *et al.*, 2015, 2022; Boyce, 2023). For example, using case studies, Kidwell (2013) found that effective PIs engage in acts of brokering. According to

Cunningham *et al.* (2014), the role of PI brings not alone professional prestige but also new responsibilities beyond research leadership and management. Furthermore, O'Kane *et al.* (2015) identifies four categories of PIs, and such categories emerge from PIs' posture (reactive/proactive) and degree of conformance. More proactive PIs utilizie non-conformance strategies to shape new research trajectories, while more reactive PIs use conformance strategies predominantly to pursue and deepen existing trajectories. PIs are better placed than technology transfer office (TTO) managers to act as boundary spanners in bridging the gap between science and industry.

PIs who act as explorative entrepreneurs deploy their activities both within the scientific community and in interaction with policy makers, firms or the society at large (Romano *et al.*, 2017). In interacting with non-academic actors, they move beyond their scientific trajectories. They assume their role as embedded in the broader social systems. Moreover, they can develop an entrepreneurial orientation that capitalizes intellectual property (IP) developed in their organizations by creating spin-off companies. So, they change their administrator mindset, whose object is to husband resources and reduce risks, into an entrepreneurial mindset. This shift requires PIs to transcend their pure scientific role and overcome institutional and organizational boundaries to combine technologies and markets, promoting innovation by managing knowledge communities and developing entrepreneurship. Entrepreneurial universities can stimulate PIs to act as explorative entrepreneurs by training them not only on how to further enhance and perform their science, but also on how to adopt an entrepreneurial approach as a result of as a learning process driven by the institutional enivronment. Moreover, Del Giudice *et al.* (2017) dealt with the performance of a PI acting as an explorative entrepreneur and defined some key performance indicators (KPIs) related to PIs' entrepreneurial orientation, analyzed through four macro items: (1) networking and resource acquired, (2) innovations realized, (3) technology transfer activities and (4) new spin-offs and start-ups. A PI, rather than a technology transfer manager, is best placed to bridge the gap between industry and science. It has been empirically validated that commercialization of new knowledge is likely to occur when scientists are aware of the individual benefits of commercialization, when they are able to identify the economic value of new knowledge, and when they have access to external bodies with resources and market knowledge to invest in the new knowledge (O'Gorman *et al.*, 2008). Therefore, the current work fits in the middle between the literature that categorizes PIs and defines their characteristics as explorative entrepreneurs and the literature that defines and measures the performance of such PIs in terms of final impact generated and strategic orientation adopted during the impact management process.

3. Methodology and theoretical framework

To the best of our knowledge, studies have not focused on the impact of IC assets and activities of universities on the regional IC. Moreover, studies have not developed a tool to support PIs in managing projects that exploits entrepreneurial university's IC and generate an IC regional impact. From a methodological point of view, our paper adopts a theoretical approach, which was deemed appropriate to address a gap in the literature due to the lack of models or frameworks to guide PIs in the impact generation process that underpin entrepreneurial university's IC development. Our study applies deductive process from existing knowledge. Conceptual deduction is an established trend in management literature (Meredith, 1993). Such contributions enhance the knowledge on constructs and their relationship, thus generating new insights (Shepherd and Suddaby, 2017). This approach has been adopted by other papers in the attempt to develop IC measurement models applicable in specific fields (see Käpylä *et al.*, 2012; Romano *et al.*, 2014a).

Our research entailed an extensive study of existing literature on the topics of entrepreneurial universities, the role of PIs and IC and, subsequently, the attempt to derive a tool and a report that could both provide a structured theoretical representation and a practical instrument for PIs concerning how research impact should be generated and monitored. The tool and the report are therefore the result of a process aimed to identify some concepts and the interconnections existing among them (Whetten, 1989). The IC-based Research Impact Management (ICRIM) we propose indicates a path for PIs in making their strategic decisions, focusing on promoting innovation and generating a broad IC impact and it is based on two tools: the IC-based Research Impact Tool (ICRIT) and the IC-based Research Impact Report (ICRIR).

3.1 IC-based Research Impact Tool (ICRIT)

To develop ICRIT, we draw on the canvas business model (Osterwalder and Pigneur, 2010). Business model innovation has become an important tool for organizations to rethink their value creation process and identify new ways of creating value for their customers and for themselves (see Amit and Zott, 2012; Magretta, 2011; Rumelt, 2012). The discussion on business models takes place at the firm-level (Siggelkow, 2017; Tikkanen *et al.*, 2005). Some scholars have also proposed that the analysis of business models should not be restricted to a firm -or a business unit-level only (Magretta, 2002; Chesbrough and Rosenbloom, 2002). Building on their arguments, we propose a business model for research project developed by PIs in an entrepreneurial university. Our framework applies the logic of a business model to impact management, comparatively evaluating project costs (publicly funded) along with project results in terms of assessing (*ex ante*), measuring (day by day) and controlling (*ex post*) outputs, outcomes and impacts.

ICRIT represents how the research project co-creates value for all the stakeholders. Understanding and rethinking the research project can better orient PIs' actions, it allows to capture opportunities to be exploited and enable to easily identify non-productive activities to be eliminated. Impact management adopting the ICRIT leads to greater and more significant results allowing to plan, monitor and report outputs, outcomes and impacts.

This tool is a simplified representation of the research logic that can be understood as a common language in the research team. Through such a visual representation, the complexity of a research project can be handled successfully, helping identify and understand the relevant elements in a specific domain and the relationships between them (Uschold and King, 1995). Therefore, as for the business model, an ICRIT helps capture, visualize and communicate the logic of a project. Once a project is mapped and understood within such a framework, the foundations to reinforce PI's proactive capacities to respond to external pressures have been created. Moreover, it aligns research and economic value, thus enabling the realization of an element of an entrepreneurial university that of promoting and contributing to innovation.

3.2 IC-based Research Impact Report (ICRIR)

The ICRIM process requires PIs to adopt the above-described tool in addition to following a procedure of ICRIR. The final objective is to generate and be able to assess the largest impact possible in the form of new incremental wealth generated by the research project or infrastructure in the region. The incremental wealth can take different forms depending on the impact type and can affect different types of beneficiaries. Reporting impact means to monitor several KPIs concerning the different fields in which the project can generate outcomes and, consequently, impact. We propose the following categories of impact to be monitored.

- *Direct economic impact*, i.e. related to money transferred in the form of wages paid, taxes and profits reinvested.
- *Indirect economic impact*, generated through the production chain made up of suppliers of goods and business services directly related to the sector analyzed.
- *Induced economic impact*, generated through expenses and consumption induced by the direct and indirect impacts.

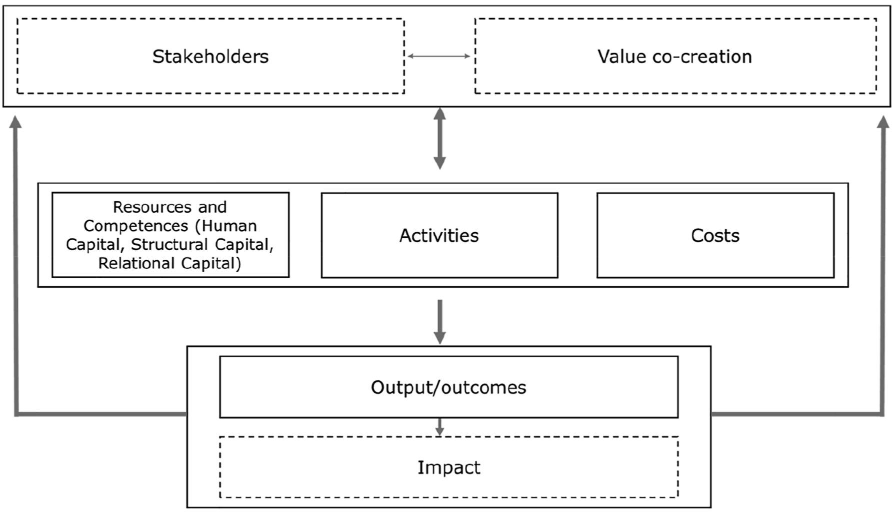
- *Social impact*, deriving, among other things, from the value of the patents, of spin-offs, scientific publications, the human capital formed, by the knowledge spillover.
- *Environmental impact*, linked to the benefits concerning some environmental objectives.

For each category, we elaborated a list of KPIs that PIs are typically called to report during the project and when it is completed. The sum of the individual values provides the total estimate of the impact generated by the infrastructure. We propose the categorization of the identified impacts into the three dimensions of IC. In this context, entrepreneurial universities, through joint projects with other organizations can assume a critical role to foster the enhancement of all the three components of IC: local human capital, the set of competences existing in the region; local relational capital, that depends on the quality of relationships and interactions between actors creating local economic growth; local structural capital, corresponding to the values, traditions and culture embedded in the region (Trequattrini *et al.*, 2018). The role of entrepreneurial universities in increasing local IC seems to represent one of the crucial factors affecting the local economic growth and the regional attitude to compete at global level.

4. Findings and discussion

4.1 IC-based Research Impact Tool

Based on the previous discussed theoretical framework, ICRIT has been developed as represented in Figure 1. First, it is important for PIs to define the stakeholders of the project they are coordinating (see Cunningham *et al.*, 2018) and to specify the value to be co-created with each of them. The connection between stakeholders and impacts is given from the output/outcomes, in the sense of results of the value co-creation, finally, going beyond output/outcomes, measuring the impact. In addition, to obtain output/outcomes, it is important for PIs to define the activities of the project they are coordinating. For each stakeholder, to specify the resources to be co-created with them and the costs. The remaining of this section analyses and discusses the different building blocks of the proposed model.



Source(s): Authors' own elaboration

Figure 1. Intellectual capital-based research impact tool

4.1.1 Stakeholders. The orientation of the PI in an entrepreneurial university should give the opportunity to undertake projects of territorial strategic development, by collaborating within the regional stakeholders. Focusing on stakeholders is essential to any business project and the same goes for research projects (Cammarano *et al.*, 2022). Stakeholders are those who commercialize the research that can address real technological, social and economic needs. When analyzing stakeholders, it is essential to keep in mind that different stakeholders have different value requirements (see Cunningham *et al.*, 2018). For a research project, the major stakeholders could be industry or government. The orientation typical of entrepreneurial universities allows the organization to intervene at all stages of the innovation process, expanding its opportunity to undertake projects of territorial strategic development, where the main actors are companies and other institutional actors. On the other hand, industry needs to access and use the knowledge assets and skills developed within the entrepreneurial university, above all in a highly competitive production system. On the other hand, also from the government perspective, research can generate social value and direct/indirect economic returns. To create and maintain connections with stakeholders is an important issue both for the PI and the research team realised through intense networking and relationship management. The TTO of the entrepreneurial university can also provide support. Moreover, *ad hoc* Information and Communication Technology (ICT) platforms can be a strategic instrument to maintain direct connections with the industrial and institutional world.

4.1.2 Value co-creation. Value co-creation can be defined as the vision of the benefits to create for and with the stakeholders (Bagchi and Tulskie, 2000; Rupo *et al.*, 2018). It is an overall view of the project that represent value for each stakeholder, and the one of the roles of a PI is to understand the value motives of each stakeholder (Cunningham *et al.*, 2018). Value co-creation is essential.

Focusing on the right side of the Research Impact Tool, we can find elements able to influence output and outcomes as well as impact: *Activities, Resources and Competences, Costs*.

4.1.3 Activities. First, it is necessary to develop a sequential activity plan of the research project and to understand what can be run in parallel. Activities are at the heart of what a project realizes and are the actions the research team performs to create value. Effective planning will typically ensure the execution phase of a project runs very smoothly, barring any unforeseen issues. Clearly defining the work and breaking it into small work units/packages, developing a sequential key activity plan (step 1, step 2, etc.) and understanding what can be run in parallel are crucial factors. Once these work units/packages are defined, resources can easily be assigned based on availability and skill sets.

Networking activity plays a central role providing access to resources that the research team does not own. Networking can provide access to information, markets, technology, knowledge and other important resources (Hitt *et al.*, 2001). The PI of a research project has to consolidate the network, the key partners of the project and is of a managerial challenge experienced by PIs (Cunningham *et al.*, 2014). Networks play a central role primarily because they provide access to resources that the research team does not own, enhancing, like for a firm, its competitive position.

4.1.4 Resources and competences. Resources and competences represent the most important assets for a PI's research project. Along with the activities, a PI must focus on when implementing a project and represent an important asset to a research project. Adopting IC theoretical lenses, we can distinguish between human, structural and relational IC resources. Human capital refers to the collective knowledge, skills and abilities possessed by individuals; structural capital consists in tangible and intangible assets, including operations, information stored in databases; relational capital refers to the connections and interactions taking place with stakeholders and the surrounding environment (Edvinsson and Malone, 1997; Bontis *et al.*, 2000). Human capital includes people's knowledge, skills and experiences that enable to create value with tangible and intangible resources (Moon and Kym, 2006). Reflecting on their core capabilities, human resources help PIs to streamline its micro-organization and build the research project competitive advantages.

Structural capital includes culture, processes, information systems and intellectual property (Moon and Kym, 2006). In the context of a research initiative, tangible resources include plants, equipment and cash balance. Intangible resources include patents, copyrights, reputation, brands, know-how and trade secrets. ICT resources can have a very strong influence on the ways activities are organized: the use of databases for managing customer and partner related information, project website etc. ICT helps the research group to provide stakeholders with ever richer information (Evans and Wurster, 1997) and to seek rapid feedback from end users to support product or service development. Relational capital consists in all those relationships and interactions with customers, partners and the community at large (Moon and Kym, 2006). In the research context, it includes the entire set of stakeholders, as described above. Proactive PIs are consistently building relational capital within and beyond their PI role (see O'Kane *et al.*, 2015).

4.1.5 Costs. As in a business model, even in the ICRIT, while evaluating project impacts, PIs need to control and access project costs. Costs represent things such as key resources that need to be acquired, costs of performing key activities and working with key partners. PI needs to measure all the costs the team incurs in creating and delivering value.

4.1.6 Output and outcomes. Expected results in the short/mid-term should be defined to orient PI's activities. The outcomes could also be represented by income derived by services and after-sale services offered to companies along with other standard outcome measurements. Income may also arise from selling or licensing intellectual property rights. The revenue streams stakeholders can be captured from the project are pivotal to its long-term sustainability. Short-term results need to be monitored to keep track of the advances made toward the final impact expected. Monitoring the work in progress is even more important when a strategic explorative perspective is adopted by PIs because a full knowledge of the state of the art helps them strategically plan future actions to enhance the overall performance.

The performance of networking and resources acquired can be measured with some indicators, such as numbers of relations activated with industry for projects, both financed and not, new research projects presented to a funding agency (competitive tenders), new research projects financed (competitive calls); contributions received for research; agreements for research and consultancy financed by third parties, not public funding agencies. The entrepreneurship performance of PIs can be strictly linked to invention and innovation. Key indicators related to innovation could be the number of invention disclosures, patent applications, patents obtained and patents currently active.

Key indicators for PIs' entrepreneurial performance related to technology transfer activities. This can be measured using the following indicators: the number of confidentiality agreements, the number of new license agreements, number of licenses active at the present, earnings from licenses, technology transfer agreements, earnings from technology transfer agreements, material transfer agreements (MTA). Finally, aptitude for entrepreneurship could be measured in terms of the start-ups created both by the PI and by their team. Therefore, the entrepreneurial aptitude of PIs can also be quantified by how they facilitate the entrepreneurial orientation of the team measured as new business ideas generated, number of ideas that turn into business plans, number of new academic spin-offs created, academic spin-offs active at the present, academic spin-offs active, with university investment, academic spin-offs active, with company investment, academic spin-offs active, with venture capitalist investment. Other outputs concern the exchange of information and ideas among individuals taking part in the project. This implies to measure what are called organizational and social capital. Concerning human capital involved in the research activity, it is appropriate to periodically keep track of new personnel employed, distinguishing between distinguishing between the various professional figures and academic employees. Finally, from a purely academic point of view, it is also necessary to monitor the number of new scientific publications to monitor whether and how the initiative is contributing to the production of novel knowledge.

4.1.7 Impact. Impacts are long-term results, and they may not be achievable even during the life cycle of the project. They should be strictly related to value co-creation. The following section we examine in depth the IC-based Research Impact Report that we proposed as complementary to the IC-based Research Impact Tool within our IC-based Research Impact Management approach.

4.2 IC-based Research Impact Report

As far as the ICRIR is concerned, below we propose the categorization of the identified impacts into the 3 dimensions of IC (see Table 1).

Table 1. IC-based research impact report

IC dimension	Direct economic impact (α)	Indirect economic impact (β)	Induced economic impact (γ)	Social impact (δ)	Environmental impact (ε)
Human capital				δ4 Human capital education δ6/δ7 Knowledge spillover supply chain/scientific community δ8 Scientific attractiveness of the territory	
Structural capital	α1 Wages paid α2 Taxes paid α3 Profits reinvested	β1 Liquidity re-introduced, for initial investments β2 Liquidity re-introduced for operative activities β3 Liquidity re-introduced for collaborations with strategic suppliers	γ1 Effects induced by investments γ2 Effects induced by operative costs γ3 Effects induced by the consumption by employees and collaborators	δ1 New businesses generated by the infrastructure or project; δ2 Value of patents on the market δ3 Value of scientific publications δ5 Services to the territory	ε1 CO_2 reduction ε2 Climate change mitigation ε3 Adaptation to climate change ε4 Sustainable use and protection of resources ε5 Transition towards the circular economy
Relational capital				δ6/δ7 Knowledge spillover supply chain/scientific community δ8 Scientific attractiveness of the territory δ9 FDI δ9 Image enhancement δ10 Value of non-use	

Source(s): Authors’ own elaboration

4.2.1 Direct economic impact. The direct impact aims to measure the effect of the research project or infrastructure through the determination of money transferred in the form of wages paid to employees and collaborators, taxes and profits reinvested. In detail, the measures of the direct impact are the following.

(1) α1 – Wages paid.

(2) α2 – Taxes paid.

(3) α3 – Profits reinvested.

4.2.2 Indirect economic impact. The measurement of the indirect impact is linked to the turnover generated by the research project or infrastructure for its suppliers, divided by sector. This level of impact measures the amount of money transferred in favor of suppliers, both in relation to investments and to operation costs. The indirect impact is due to the liquidity reintroduced in the territory for activities of local partners and suppliers. In detail, the indirect impact includes the items listed as follows.

(1) β1 – Liquidity re-introduced, at local, national and international level, for initial investments.

(2) β2 – Liquidity re-introduced for operative activities.

(3) β3 – Liquidity re-introduced for collaborations with strategic suppliers.

4.2.3 Induced economic impact. The study also intends to measure the induced impact, given by two measures. On one hand, the impact on the economic system deriving from the presence of sectoral interdependencies between the various sectors, generating a multiplicative effect that can be measured through the input–output tables. On the other hand, the effect on the purchasing power of workers directly connected to the economic activity generated. In detail, the induced impact includes the following effects.

(1) γ1 – Effects induced by investments.

(2) γ2 – Effects induced by operative costs.

(3) γ3 – Effects induced by the consumption of durable and non-durable goods by employees and collaborators.

4.2.4 Social impact. The project is also able to generate a social impact to measure in financial terms. The social impact includes the following.

(1) δ1 – New businesses generated by the infrastructure or project: New businesses have already been created, and others will be created both locally and nationally to take advantage of the opportunities offered by the research project.

(2) δ2 – Value of patents: Technological innovation and R&D activities play a leading role in economics. It is important to calculate the economic value generated by the patent activity, which allows a knowledge spillover from which companies and the whole regional and national territory benefit from the increased competitiveness on the market.

(3) δ3 – Value of scientific publications: Among the benefits of a research project, there is the possibility for researchers to access new data, process it and contribute to the creation of new knowledge producing scientific outputs.

(4) δ4 – Human capital education: Spillover effects in the educational domain concern the scientific, technical (technicians and engineers), administrative and support staff as well as the PhD students, postdoc researchers, young academics and other short-term users who take part in the project, enjoy training in terms of new knowledge and experience acquired.

(5) δ5 – Services to the territory: The infrastructure provides services that the territory that are freely available to firm. Some benefits in the long run can be derived from the project-based initiatives that are aimed at supporting the culture of ethics and legality, the culture of equal opportunities, the culture of disability and social inclusion, the prevention and protection of health.

(6) δ6 – Knowledge spillover in the supply chain: The technology suppliers involved in the design, construction and operation of a research infrastructure, can benefit from working with/for a research infrastructure. The companies involved in the supply chain face the challenge of providing non-commercial industrial solutions for a series of complex technological problems. This gives companies the opportunity to collaborate with the scientific and technical staff and to acquire new technological knowledge and skills. The benefit of suppliers' learning-by-doing can produce different kind of developments, ranging from improvements to existing equipment to the implementation of processes to produce new tools finding application in other sectors.

(7) δ7 – Knowledge spillover in the scientific community: Research projects produce significant knowledge also for the scientific community of reference, especially in relation to free access to data.

(8) δ8 – Scientific attractiveness of the territory: The territory concerned enjoys a flow of scientists interested in the research facilities and of outreach activities for schoolchildren, students, congress initiates that have an impact on expenses of accommodation, catering, transport. Some measures in this field may be public engagement initiatives and visitors attraction to spread scientific awareness, as well as promotional initiatives to arouse the curiosity of the new generations toward the study of certain disciplines, for example science, technology, engineering and mathematics (STEM) disciplines.

(9) δ9 – Foreign direct investment (FDI): Thanks to the increase in attractiveness of the territory in which the project is carried out or the infrastructure is built infrastructure is located and above all to the supplies needs, an increase in greenfield-type FDI flows (FDI) is estimated.

(10) δ10 – Image enhancement: The image of the university and of promoters is strengthened by the project itself both nationally and internationally, with effects on the future funding attractiveness.

(11) δ11 – Value of non-use. A further impact on social well-being is related to its discovery potential. The discovery itself, in addition to the value of publications and patents, has an intrinsic social value, and can bring about a number of new improvements in human well-being defined as the benefits of non-use.

4.2.5 Environmental impact.

(1) ε1 – Impacts on environmental objective: Depending on the project, it is possible to generate an environmental impact to be measured in economic terms, for example, the reduction of CO_2. Other measures of environmental impact could be climate change mitigation; adaptation to climate change; sustainable use and protection of water and marine resources; transition towards the circular economy, also waste reduction and recycling; prevention and reduction of air, water or soil pollution; protection and restoration of biodiversity and ecosystems.

(2) ε2 – Climate change mitigation.

(3) ε3 – Adaptation to climate change.

(4) ε4 – Sustainable use and protection of resources.

(5) ε5 – Transition towards the circular economy

The proposed model represents a framework to guide the monitoring and evaluation of the impact generated by research projects conducted as part of third mission strategies and goals within in an entrepreneurial university. These projects are fostered by IC resources and their overall impact on the development of the surrounding environment can be assessed adopting the lenses of regional IC.

Regional IC has been conceptualized as the value of the knowledge assets that fuel value creation processes of the referred region, since knowledge itself represents the foundation of all IC components (Schiuma *et al.*, 2008). All the knowledge generated by the project is leveraged to generate different kinds of long-term impact that contribute to enhance sustainable regional competitiveness. Indeed, in regional IC literature, all the IC dimensions are thought to contribute to competitive and regional development (Kohl *et al.*, 2015; Lerro and Schiuma, 2009).

5. Conclusion

Our paper provides directions for the process of impact management for joint research projects in entrepreneurial universities. We begun by examining the role of PIs who leads joint research projects and are responsible for generating and maximizing impact. Within entrepreneurial universities, scientists in the PI role acting as explorative entrepreneur through their boundary spanning activities are influential actors in shaping and driving the creation and exploitation of IC that can have direct and indirect beneficial impacts on regional IC. Our paper presents a novel research impact management approach for PIs and includes a Research Impact Tool and a Research Impact Report.

Our study has some practice implications. For entrepreneurial universities, our models can be used to support the strategic development of IC that contributes to regional IC. Entrepreneurial university leadership teams need to be aware of how they can support the development of regional IC through institutional IC policies that truly values and supports this activity across its community of faculty, students, administrative and professional service staff. This also requires leaders to adopt entrepreneurial approaches and mindsets in supporting and enabling activities at a micro level that underpins the development of IC. For entrepreneurial university leaders, professional service staff involved in supporting research and technology and knowledge transfer our IC-based Research Impact Report provides a practical way of framing and understanding the different elements of entrepreneurial universities IC. Using our IC-based Research Impact Report can complement existing approaches used by entrepreneurial universities to capture the scope and scale in this regard and could be used as part of regular reviews along with strategic planning exercises to further bolster and strengthen the development of entrepreneurial university-based IC and its direct and indirect contributions to regional IC. Moreover, it provides a basis for entrepreneurial university leaders to consider the development and support of institutional IC that is potentially aligned with the current and future needs of other entrepreneurial and innovation ecosystem actors. It is important for entrepreneurial universities as one of the anchor institutional actors in entrepreneurial and innovation ecosystems to shape, orchestrate and align their current and future IP portfolio and activities with the other actors within their regional territory. This may mean more effective long-term collaborations with other actors in the development teaching and research mission of entrepreneurial universities. It also may result in further evolutionary structural and scope change in how entrepreneurial universities engage with other ecosystem actors.

For scientists in the PI role, an increasing pressure that they face is in designing joint research projects with business and other stakeholders is that they need at the project development stage create robust and credible project impact plans that generate multiple impacts for all stakeholders. This can be a daunting task for scientists. Our Intellectual Capital-

Based Research Impact Tool enables scientists that are seeking to become a PI or those that are already in PI roles to effectively plan and realize IC that can have multiple beneficial impacts that contributes to regional IC. Our tool highlights for PIs the important role and influence that they have in shaping and driving IC within their territory and institutional setting. Moreover, our tool enables PIs to take a more strategic approach to the development of IC which is now an important element in joint research projects.

Finally, our paper generates some future research avenues. First, there is a need for cross-country studies that examines IP policies of entrepreneurial universities and how they contribute directly and indirectly to regional IC. Second, future studies should examine how entrepreneurial university leaders understand and enact IC development within their institutional settings and what are the drivers that influence their decision-making. Third, there is a need for future studies to examine the approaches that scientists in the PI role use to develop their IP and how they approach developing their IP portfolio. Fourth, we need future studies to explore the underlying factors that contribute to the non-realization of planned impact and the resultant implications for generation of IP within a regional territory. Finally, we would encourage other researchers to build on the efficacy of the framework and model presented in this paper.

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