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The next frontier: Open innovation and knowledge absorptive capacity in business incubators: Towards the experience from Chile, Israel and Italy

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Abstract

This research aims to verify the relationship between the open innovation practices and knowledge absorptive capacity in business incubators from Chile, Israel and Italy. Furthermore, this research examines how this affects the outcomes (business incubators performance). The research was conducted in the light of theoretical excerpts and application of a survey to specialists, with knowledge about the investigated object, selected by scientific and technical criteria. The data were extracted by means of a matrix of judgement in which experts made their judgments about the variables investigated. In order to reduce subjectivity in the results achieved, the following methods were used: multicriterial analysis and neurofuzzy technology. The produced results were satisfactory, validating the presented proposal.

Keywords: Open innovation practices, knowledge absorptive capacity, business incubators, business incubators performance, experience from Chile, Israel and Italy.

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1. Introduction

Recently, relevant changes have made organisational boundaries more fluid and dynamic in response to the rapid pace of knowledge diffusion (Abrahamson, 1991; Griliches, 1990; Prange & Schlegelmilch, 2018; Teece, 1986; Teece, Pisano & Shuen, 1997; Wehen & Montalvo, 2018) and innovation and international competition (Chesbrough & Rosenbloom, 2002; Christensen & Raynor, 2003; Damanpour, 1996). This helps to reconsider how to succeed with innovation (Teece, 1986; Teece et al., 1997; Wheelwright & Clark, 1992). Innovation events, such as the introduction of a new product or process, represent the end of a series of knowledge and the beginning of a value creation process that can result in improvement in a business performance marked by the ability to counteract the vulnerability of the globalisation of business. However, the ability to design and provide innovative products with a great incremental value to customers in a specific issue requires a technical expertise of different knowledge derived from the internal and external sources of knowledge (Chesbrough, 2003).

The sources of knowledge (P&D, Universities and research Centres among others) have multifaceted nature (Kline & Rosenberg, 1986; Von Hippel, 1988) and show different impacts on a company's business, since the innovation performance is strongly dependent on and boosted by knowledge and its respective sources (Frenz & Ietto-Gillies, 2009). With the widespread diffusion of knowledge, all knowledge necessary for creating innovations are no longer present within the firm's boundaries. They need to acquire knowledge from other sources. In fact, knowledge expands the potential for creating business value (Roper, Du & Love, 2008). However, the knowledge absorptive capacity is a complex challenge. Several studies have referenced the importance of the collaboration between knowledge and innovation generation (Chesbrough, 2003). This takes to evaluate the influence of innovation practices, in particular open innovation in the knowledge absorptive capacity. Open innovation is a new way of thinking of innovation for organisations, where organisations explicitly cooperate with others to create new innovations (Chesbrough, 2003). Open innovation is a model which assumes that firms can and should use external as well as internal ideas and internal and external paths to market, as they look to advance their technology (Chesbrough, 2006).

In this sense, this research aims to verify the relationship between the open innovation practices and knowledge absorptive capacity in business incubators performance from Chile, Israel and Italy. Furthermore, this research examines how this affects the outcomes (business incubators performance). Business incubators have traditionally been recognised as new organisational forms for promoting entrepreneurship and stimulating new business formation. Similarly, business incubation programmes, activities and events have routinely been perceived as being beneficial to entrepreneurs, startups and small business. Considering the large faith and the considerable amounts of money invested in incubators, the evaluation of performance/results is fundamental (Aernoud, 2004; Amezcua, 2010; Chan & Lau, 2005; Chandra & Medrano Silva, 2012; Lindholm-Dahlstrand & Klofsten, 2002; Lyons & Li, 2003; OECD, 2006; 2007; Shih & Aaboen, 2017). Systematic evaluations are needed to understand whether business incubation is effective and efficient policy tools in those countries. The evaluation of incubator performance has attracted some attention (Aernoud, 2004; Allen & McCluskey, 1990; Barbero, Casillas, Ramos & Guitar, 2012; Bergek & Norrman, 2008; Bhabra-Remedios & Cornelius, 2003; Chan & Lau, 2005; Grimaldi & Grandi, 2005).

This study attempted to cover an existing space in the literature about the relationship between open innovation practices and absorptive capacity towards the business incubators performance from Chile, Israel and Italy. As studies have been inconclusive, we argue that performance differs according to the knowledge absorptive capacity by business incubators based on the open innovation practices. The article is divided according to the following sections: methodology, verification of the conceptual model and subjacent analyses, and conclusions and implications.

2. Theoretical background

2.1. Open innovation, knowledge and absorptive capacity

The open innovation paradigm (Chesbrough, 2003) can be characterised by its porous innovation process, and the strong interaction of the company with its environment. By integrating a large number of individuals into the innovation process, new creativity and know-how are brought into the organisation (inbound open innovation). Von Hippel (1988) suggested using lead users and other stakeholders as external sources of innovation (Schroll & Mild, 2011) that not only can this attract more talent but also can transfer idle innovative ideas and R&D technology externally to other companies. Enterprises use the concept of open innovation, in which internal innovative ideas can flow outward and the external ideas and technologies can flow inward within an enterprise. The open innovation approach explores knowledge acquired from external sources (competitors, universities and partners) (Greco, Grimaldi & Cricelli, 2016). Business exposure to internal and external knowledge promotes the generating value (St-Jean & Audet, 2012). In this perspective, knowledge emerges as one of the most important strategic resources for the companies. Many authors discuss prerequisites of successful open innovation. Robertson, Casali and Jacobson (2012), for example, deal with different types of absorptive capacity which are needed in an open innovation process. Accessive capacity is about knowledge generation and gathering both from the internal and external sources. Absorptive capacity is one of the most important concepts developed in business research over recent years. Outside sources of knowledge could be essential to the innovation process and to companies innovation capabilities, as well as the ability of a firm to recognise the value of new, external knowledge, assimilate and integrate the new knowledge, and apply it to commercial ends. Potential absorptive capacity includes a company's ability to acquire and assimilate knowledge, while the realised absorptive capacity focuses on knowledge transformation and exploitation, which in turn generates potential competitive advantages. Zahra and George (2002) further propose several propositions connected to potential and realised absorptive capacity (Vie, Stensli & Lauvas, 2014):

- The greater a firm's exposure to diverse and complementary external sources of knowledge, the greater the opportunity is for the firm to develop its potential absorptive capacity.
- Experience will influence the development of a firm's potential absorptive capacity.
- Activation triggers will influence the relationship between the source of knowledge and experience and potential absorptive capacity.
- Use of social integration mechanisms reduces the gap between potential and realised absorptive capacity, thereby increasing the efficiency factor (*r*).

Introduced by Cohen and Levinthal (1989; 1990), the absorptive capacity refers to learning processes that are fundamental to the survival of a company in the long term because they complement or readjust company knowledge (Gonzalez-Campo & Hurtado-Hayala, 2014). Studies at that time highlighted the fundamental role that the acquisition and application of new knowledge played in business competitiveness (Hutabarat & Pandin, 2014). Absorptive capacity enables firms to use knowledge obtained from outside efficiently (Matusik & Heeley, 2005) and to convert this knowledge to outputs having economic value (Murovec & Prodan, 2009). Therefore, it is a dynamic capacity to have a major impact on gaining competitive advantage (Camison & Fores, 2010). Cohen and Levithal (1990) define the absorptive capacity as 'an ability to recognise the value of new information, assimilate it and apply it to commercial ends' (Ince, Zeki & Turkcan, 2016). Lane and Lubatkin (1998) examine the absorptive capacity in inter-organisational context and explained the context in firm pairs which are student and teacher firm having relative characteristics. Zahra and George (2002) reconceptualise the concept and define as 'a set of organisational routines and processes by which organisations acquire, assimilate, transform and exploit knowledge to produce a dynamic organisational capability' (Ince et al., 2016). Since Cohen and Levinthal's seminal work, many empirical and theoretical studies have explored the concept of the absorptive capacity from the

perspective of different analytical units and modelling strategies (Newey & Shulman, 2004). Of particular interests are those by Van Den Bosch, Volberda and Boer (1999) and Zahra and George (2002), which take the firm as the basic unit of analysis.

The main contribution of Van Den Bosch et al. (1999) was to suggest that the firm's knowledge environment could influence the development of its absorptive capacity (Hutabarat & Pandin, 2014). The absorptive capability is a process involving four diverse and complementary stages or dimensions: acquisition, assimilation, transformation and exploitation (Sanchez-Sellero, Rosell-Martınez & Garcıa-Vazquez, 2014; Zahra & George, 2002). Todorova and Durisin (2007) suggest that the absorptive capacity has four dimensions: recognition, acquisition, assimilation or transformation and exploitation. Acquisition is the ability to acquire critical external knowledge (Zahra & George, 2002). Assimilation is the ability to absorb and internalise the acquired knowledge (Camison & Fores, 2010). Transformation is the ability to convert assimilated knowledge into own firm's routines (Jimenez-Barrionuevo, Garcia-Morales & Molina, 2011). Exploitation is the ability that enables firms to improve current competencies and to create new things by using transformation knowledge (Ince et al., 2016; Zahra & George, 2002).

2.2. Business incubators

Entrepreneurship and innovation have been widely accepted as essential sources of business success, high-value-added job creation and national economic development. A wide array of mechanisms is being promoted to support innovative entrepreneurship. The most researchers seem to agree that incubation is related to the early phase of a venture's life (Aernoud, 2004; Bhabra-Remedios & Cornelius, 2003; Allen, 1985; Bergek & Norman, 2008; Grimaldi & Grandi, 2005; Hackett & Dilts, 2004a; Lindelof & Lofsten, 2004; Smilor & Gill, 1986; Temali & Campbell 1984).

The most incubators take on ventures in early phases, whose ideas are immature, i.e., have not yet been fully developed into business ideas (Klofsten, 2005), and help develop them into viable companies. The first incubator was established in 1959 in Batavia, New York, USA. From the 1970s onward, business incubators have spread out all over the world (Albert & Gaynor, 2001). Although it originated in the US, incubation is now a worldwide phenomenon that has spread to countries as diverse as the UK, France, Sweden, Italy, the Philippines, China and Brazil (Kalis, 2001; Rice & Matthews, 1995). Next, some characteristics related to the context of the incubators consulted by country—Israel, Chile and Italy—are presented.

Chile: The business incubators in Chile are supported primarily by a coalition of government and universities (Chandra & Medrano Silva, 2012; Chandra & Narczewska, 2009): The Government promotes the national initiative of innovation and R&D; generates jobs, incomes and taxes; promotes regional development; forms partnerships with industry and universities and creates dialogue between key stakeholder groups. The primary focus is on fostering innovative companies with high growth potential, and the government also looks for economic impact in terms of job creation in economically disadvantaged regions (Chandra & Medrano Silva, 2012; Chandra & Narczewska, 2009).

Israel: The Israeli innovation incubators programme was adapted from the experience of other countries, mainly the US. As implemented, the programme has shown a strong specificity and homogeneity, both in its content and its rules of implementation. During the past decade, the Israeli high-tech industry has rapidly expanded, with one of the highest rates of startups in the world. High-tech is the major driver of the Israeli economy, emphasised by a growth rate which is the highest of all Israeli industrial sectors (Dvir & Tishler, 1999; Lerner & Hendeles, 1996; Reychav & Weisberg 2010; Senor & Singer, 2009). After a serious economic crisis at the beginning of the 1980s, Israel decided to make a concerted effort to improve the realisation of its science and technology potential, which until then had been largely the domain of its seven main internationally recognised universities and research centres, with the business arena being excluded for the most part. Government intervention

through its OCS branch is seen as having been a crucial factor in boosting the performance of the Israeli economy (Trajtenberg, 2001). The performance of the innovation incubators programme is still an open issue, particularly because few indicators of performance are available other than project graduation rates. On the one hand, it can be said that the incubators have provided job opportunities with valuable *in situ* business and commercial training as well as networking resources when a specific population needed them and when financial capabilities in the local economy were nearly non-existent. Furthermore, one should not forget that the incubator programme was initiated to foster the sustainable integration of Russian immigrants with scientific and technological skills but poor language proficiency and no business experience (Bank & Almor, 2013; Senor & Singer, 2009).

Italy: The Italian incubators were originated in the 1980s by the initiative of the public sector in order to promote entrepreneurship and economic development, especially in economically disadvantaged areas of the country. In particular, the Society for the Entrepreneurial Promotion and Development (SPI), from the public sector, played a significant role in the creation of the first business incubators in the form of the Business Innovation Centre (BIC), oriented to the model proposed by the European Commission and mainly specialised in high-tech production areas (Astolfi, 2014).

3. Designer of research

3.1. Conceptual model framework: Constructs and hypotheses

This section examines the conceptual model (Figure 1) and presents the hypotheses to be tested throughout this work.

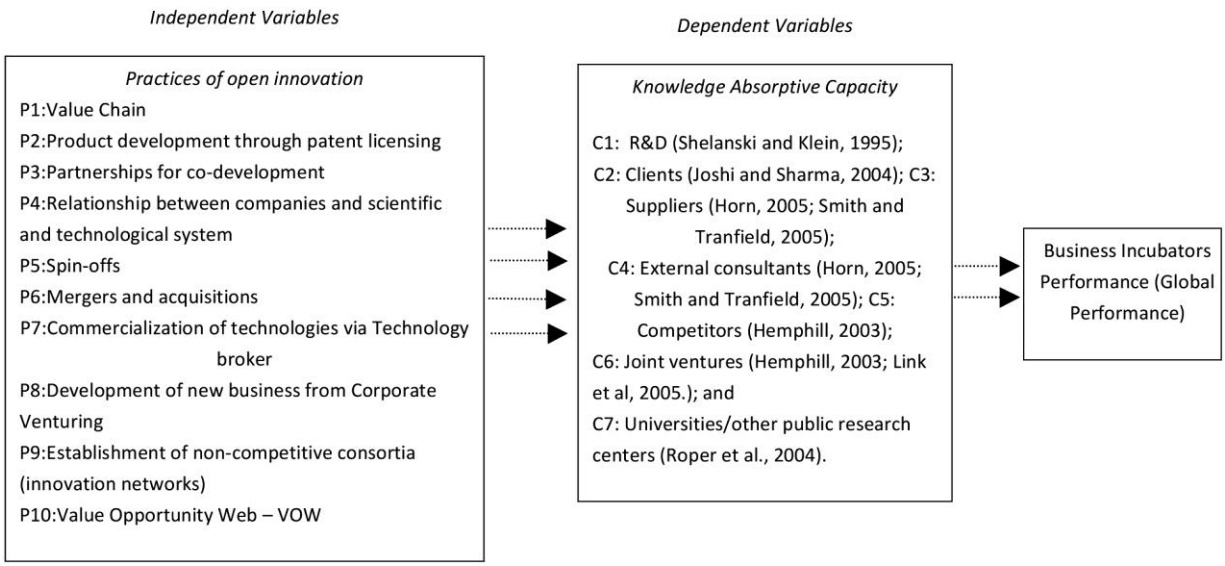

Figure 1. Conceptual model

The current study proposes a conceptual framework for a specific model designed to explain the link between the innovation capacity and innovation performance in business incubators from Chile, Israel and Italy. Figure 1, which illustrates the essential constructs included in this study, will serve to guide subsequent discussions. Relying on the literature review, the current research proposes that innovation activities in the business incubators will improve the results of incubators in the three countries. From the conceptual model, the following independent variable, dependent variable and hypotheses were made:

Independent variables: from the findings in the literature (Lopes & Teixeira, 2009), the following open innovation practices were identified (Trentini, Furtado, Dergint, dos Reis & de Carvalho, 2012).

Value chain: the value chain of innovation is one of the most popular practices, because it increases significantly the incremental value of the business. Chesbrough (2006) shows that open innovation assumes that useful knowledge is widely distributed and that even more capable of organisations of R&D should identify, connect and boost external sources of knowledge as an elementary process for innovation.

Product development through patent licensing: it is a very common practice. The occurrence of technology licensing has been mainly concentrated in the chemical industry—pharmaceutical, electrical and electronic equipment, computers and industrial machinery.

Partnerships for co-development: it is a practice that has become business models that enable increasing innovation reducing P&D costs and facilitate the expansion and dissemination of innovation.

The Relationship between companies (Business incubators) and scientific and technological system: it is a practice that enables the research developed at universities and research centres supports the industrial requirements, allowing the specialisation of each entity with return for both parties. Moreira et al. (2009) report some of the challenges to be overcome, such as: relationship difficulties, lack of communication, divergent goals and visions, deadline mismatches, the distribution model of knowledge in universities which hinders the identification of researchers and research made, and the steps of assessment and valuation of technologies.

Spin-offs are companies created to develop opportunities generated by the parent company. They aim to explore new business conditions in order to minimise negative impacts on the parent company. In this kind of practice, projects that do not have any internal interest may generate new business.

Mergers and acquisitions: Mergers and acquisitions are aimed at absorbing knowledge and external technology, allowing a faster establishment in new markets and impeding the entry of new competitors, as well as reducing costs and increasing the possibility of releases.

Commercialisation of technologies via Technology broker: it is a practice of open innovation in which a professional assists in finding, rating, marketing and managing the transfer of certain technology/knowledge through a network of contacts.

Development of new business from Corporate Venturing: it is a form of investment in which companies invest capital in new-born businesses with innovations that may or may not be related to the business and have a high level of risk, but with great potential for growth.

Establishment of non-competitive consortia (innovation networks): it is a collaborative practice in which P&D companies associate with universities, research centres or competing companies with the goal of generating knowledge and products that would hardly be possible in an individual way.

Value Opportunity Web (VOW) is a practice of capturing and analysing potentially valuable data on the external environment and transforming that information into winning products for consumers. The goal of a VOW is to analyse the data obtained taking into account new needs, new ways of doing things, new product features and new models the company may deliver value to the customer.

Dependent variables: The independent variables were extracted from the specialised literature and assessed by experts for confirmation. The following independent variables were identified: Stakeholders' knowledge: C1: R&D (Shelanski & Klein, 1995); C2: Customers (Joshi & Sharma, 2004); C3: Suppliers (Horn, 2005; Smith & Tranfield, 2005); C4: External consultants (Horn, 2005; Smith & Tranfield, 2005); C5: Competitors (Hemphill, 2003); C6: Joint ventures (Hemphill, 2003); and C7: universities/other public research centres (Ropper et al., 2004). For the Customer dimension, the construction used is based on Joshi and Silva (2004); Terziovski and Samson (1999). For the suppliers variable (Horn, 2005; Smith & Tranfield, 2005), the content was derived from the construction used by Forza and Filippini (1998). For the R&D variable, the construct was mainly derived from Shelanski and

Klein (1995); Gupta, Wilemon and Atuahene-Gima (2000) and Chiesa et al. (1996), which capture two important R&D aspects: capabilities and connections. As for the variable External Consultants, the construct is based on Horn (2005); Smith and Ranfield (2005). The variable Competitors is based on Hemphill (2003); Link et al. (2005). Finally, the variable Joint Ventures is based on Hemphill (2003). From the conceptual model, the following hypotheses were made: Hipothesis—*H1*: The practices of open innovation influence to a greater or lesser degree the knowledge absorptive capacity in business incubators from Chile, Israel and Italy. *H2*: The optimal rate of global performance of the business incubators depends on the combination and interaction of the influence of the practices of open innovation in the knowledge absorptive capacity in business incubators from Chile, Israel and Italy.

3.2. Research design

3.2.1. Sample and data collection

The population of this study was in business incubators in Chile, Israel and Italy (Survey). The authors investigate the innovation capacity on the innovation performance in business incubators from Chile, Israel and Italy. The data were extracted using an assessment matrix (questionnaire scalar). The interview instrument for the semi-structured, in-depth interviews was developed after a thorough literature review. The instrument was pre-tested with business incubators managers. The pilot interviews served as a pre-test for instrument validation and changes were made to the interview instrument based on the findings and comments. The instrument was translated into Spanish, English, Italian and Hebrew. The actual survey was carried out between March and June 2014, which involved 95 specialists. The samples were selected by random sampling technique. Of the 87 specialists in our sample, 80 completed questionnaires were retuned. However, seven cases had to be excluded from further analysis due to excessive missing data. Therefore, the present sample comprised of 80 specialists in business incubators in the three countries resulting in a response rate of 82%. The number of respondents in this study is sufficient to carry out the analysis.

The questionnaire was sent to the respondents through email. The self-administered questionnaire was chosen as the mode for data collection. Respondents were given one month to complete the questionnaire. After one month, emails were sent to remind the respondents that the questionnaire should be sent out to the researchers. Respondents who do not yet complete the questionnaire were given another additional month to complete it. The specialists have experience in innovation, business, technology, knowledge, business incubators, project management in incubators investigated, and with the following skills: Managers of business incubators and staff, policy makers (government) and academics, director, managers, engineering, senior R&D engineer, director of research and innovation and director of new technologies and innovation. In Chile, the data were collected from managers of 22 business incubators and specialists. In Italy, the data were collected from managers of 39 business incubators. In Israel, the data were collected from managers of 26 business incubators and specialists. To reduce subjectivity in the results achieved, the following methods were used complementarily and in combination: Law of Categorical Judgments psychometric scaling method (Thurstone, 1927), multicriteria analysis, and neuro-fuzzy technology. Next, these procedures are detailed.

4. Conceptual model verification and underlying analyses

To solve the research problem and achieve the desired goal, the practices of open innovation of the business incubators were identified and then evaluated according to their effects on the knowledge absorptive capacity according to the respective sources of knowledge. Finally, the optimal rate of the value is modelled from the interaction between all dependent variables.

Phase 1: Modelling of the influence of the Open Innovation practices in the knowledge absorptive capacity of the actors (sources).

This phase is systematised in the following steps:

Step 1: identification of the practices of open innovation. Thus, the following practices of open innovation from the specialised literature were identified and confirmed by experts: Value Chain; Product development through patent licensing; Partnerships for co-development; Relationship between companies and scientific and technological system; Spin-offs; Mergers and acquisitions; Commercialisation of technologies via Technology broker; Development of new business from Corporate Venturing; Establishment of non-competitive consortia (innovation networks); and VOW.

Step 2: identification of the knowledge from sources of knowledge

This step has been subdivided as follows: Stage 1: identification of the knowledge sources and Stage 2: identification of the knowledge from knowledge sources.

Stage 1: identification of the knowledge sources: The identification of the knowledge sources is systematised in the following (from literature): C1: R&D (Shelanski & Klein, 1995); C2: Clients (Joshi & Sharma, 2004); C3: Suppliers (Horn, 2005; Smith & Tranfield, 2005); C4: External consultants (Horn, 2005; Smith & Tranfield, 2005); C5: Competitors (Hemphill, 2003); C6: Joint ventures (Hemphill, 2003); and C7: universities/other public research centres (Roper, Hewitt-Dundas & Love, 2004).

Stage 2: Acquisition of the knowledge from knowledge sources

This stage has systematised the Acquisition of Knowledge from knowledge sources. Acquiring the knowledge (from specialists) implies, according to Buchanan (2002), Eliufoo (2008); Fletcher, Yiannis and Polychronakis (2007), Wu (2008), the obtaining of information from specialists and/or from documented sources, classifying it in a declarative and procedural fashion, codifying it in a format used by the system and validating the consistency of the codified knowledge with the existent one in the system. Therefore, at first, the way the conversion from information into knowledge (Herschel, Nemati & Steiger, 2001) dealts with, which is the information to be understood by and useful for the decision making in business incubators. First, the information is gathered (from knowledge sources: C1: R&D (Shelanski & Klein, 1995); C2: Clients (Joshi & Sharma, 2004); C3: Suppliers (Horn, 2005; Smith & Tranfield, 2005); C4: External consultants (Horn, 2005; Smith & Tranfield, 2005); C5: Competitors (Hemphill, 2003); C6: Joint ventures (Hemphill, 2003); and C7: Universities/other public research centres (Roper et al., 2004). Then, the combination and internalisation are established by the explicit knowledge (information) so that it can be better understood and synthesised in order to be easily and quickly presented whenever possible (the information must be useful for decision making and for that reason, it must be understood). In this work, we aim to elaborate the conversion of information into knowledge. The conversion (transformation) takes place as follows: first, the comparison of how the information related to a given situation can be compared to other known situations is established; second, the implications brought about by the information for the decision-making are analysed and evaluated; third, the relation between new knowledge and that accumulated is established; fourth, what the decision makers expect from the information is checked. The conversion of information into knowledge is assisted by the information maps (elaborated in the previous phase by areas, through analysis and evaluation of the information).

We highlight that the information taken into account is both the ones externally and internally originated. The information from the external origins has as the main goal to detect, beforehand, the long-term opportunities for the business incubators (Eliufoo, 2008). The internal information is important to establish the strategies, but it has to be of a broader scope than that used for an operational management, because besides allowing the evaluation of the performance, it also identifies its strengths and weaknesses. Following from this, the proceedings for the acquisition of the theoretical background and concepts are dealt with. Such proceedings begin with the areas of information (from business incubators activities/areas/department), one by one, where the concept and the theory, on which it is based, and the performance of the actions (articulations) developed in those areas that allow to guarantee the feasibility of the business incubators are identified.

In other words, which knowledge and theory are required to be known in order to ensure the success of the business incubators in that area? Then, the analysis of surveys in institutions takes place bearing in mind the demands of similar areas studied in this work. As for the offer, we intend to search for the level of knowledge required by the business incubators in those areas, as well as what concerns technical improvement (means) for the professionals. This stage determines the concept of knowledge to be taken into account on the development of this work. Therefore, for the operational goals of this work, we have adopted them as the 'contextual information' and the theoretical framework and concepts. The results (Knowledge) from knowledge sources are: R&D knowledge; Clients knowledge; Suppliers knowledge; External consultants knowledge; Competitors knowledge; Joint ventures knowledge; and Universities/other public research centres knowledge.

Step 3: Evaluation of the influence of practices of open innovation in the knowledge absorptive capacity in business incubators

This procedure was developed using the multi-criteria analysis Electre III, Promethee II e Compromise Programming. Next, these procedures were detailed. The methods used were Compromise Programming, Electre III and Promethee II. The results achieved confirm Hipothesis—H1: The practices of open innovation influence to a greater or lesser degree, the knowledge absorptive capacity in business incubators from Chile, Israel and Italy, and assigning values to each criterion, we arrive at a matrix of Criteria × Alternatives that together with the vector weights provide the necessary support to apply the multi-criteria methods. In other words, one applies the selection and classification methodology of alternatives, using the Compromise Programming, Promethee II and Electre III methods.

The Compromise Programming due to its wide diffusion and application simplicity and understanding renders it an alternative to evaluate problems as referenced in this application. The problem solution compromise is the one that comes closest to the alternative. This method was designed to identify the closest solution to an ideal one; therefore, it is not feasible, using a predetermined pattern of distances. In Promethee II, there is a function of preferences for each criterion among the alternatives which must be maximised, indicating the intensity of an alternative to the other one, with the value ranging from 0 to 1. Of the Electre family (I–V), Electre III is the one considered for the cases of uncertainty and inaccuracy to evaluate the alternatives in the decision problem. All these methods enable to analyse the discrete solution alternatives, and taking into consideration subjective evaluations represented by numerical scores and weights. As these are problems involving subjective aspects, the methods that best fit the situation of this research are the methods of the family Electre III and Promethee II.

It should be mentioned that although the Compromise Programming method is not part of this classification, it has similar characteristics, showing much simplicity in order to understand its operation, which makes it feasible for this application. The results produced by this prioritisation enable managers to better focus their efforts and resources on managing the practices of open innovation that performs best, which results in achieving the goals sought by the companies The structure of this prioritisation (classification by hierarchical analysis) is proposed at three planning levels in a judgment matrix, in which at the first hierarchical structure level, it defines the goal, which is to achieve the value creation of the companies that will feed the system; the criteria are in the second level, which are the knowledge (prospecting) of sources: K1: R&D (Shelanski & Klein, 1995); K2: Clients (Joshi & Sharma, 2004); K3: Suppliers (Horn, 2005; Smith & Tranfield, 2005); K4: External consultants (Horn, 2005; Smith & Tranfield, 2005); K5: Competitors (Hemphill, 2003); K6: Joint ventures (Hemphill, 2003; Link et al., 2005.); and K7: universities/other public research centres (Roper et al., 2004).

The practices of open innovation of the companies are in the third level, the alternatives, which are: *P1: Value chain; P2: Product development through patent licensing; P3: Partnerships for co-development; P4: Relationship between companies and scientific and technological system; P5: Spin-*

offs; P6: Mergers and acquisitions; P7: Commercialisation of technologies via Technology broker; P8: Development of new business from Corporate Venturing; P9: Establishment of non-competitive consortia (innovation networks) and P10: VOW. The prioritisation process obeys the judgment of the evaluators (experts). With the results of the judgment matrix, the methods were applied: Promethee II, Electre III and Compromise Programming to evaluate the innovation capacities in relation to the knowledge absorptive capacity. Table 2 shows the results produced.

Table 2. Classification of practices of open innovation using multi-criteria analysis methods

Chile	Open innovation practices	Promethee II	Compromise programming	Electre III
	P1: Value chain	2ª	2ª	3ª
	P2: Product development through patent licensing	3ª	3ª	4ª
	P3: Partnerships for co-development	1ª	1ª	1ª
	P4: Relationship between Business incubators and scientific and technological system	1ª	1ª	1ª
	P5: Spin-offs	1ª	1ª	1ª
	P6: Mergers and acquisitions	4ª	4ª	5ª
	P7: Commercialisation of technologies via Technology broker	3ª	3ª	4ª
	P8: Development of new business from Corporate Venturing	1ª	1ª	2ª
	P9: Establishment of non-competitive consortia (innovation networks)	2ª	2ª	3ª
	P10: VOW	3ª	3ª	2ª
Israel				
	P1: Value chain	2ª	2ª	3ª
	P2: Product development through patent licensing	3ª	3ª	4ª
	P3: Partnerships for co-development	1ª	1ª	1ª
	P4: Relationship between incubators and scientific and technological system	1ª	1ª	1ª
	P5: Spin-offs	1ª	1ª	1ª
	P6: Mergers and acquisitions	4ª	4ª	5ª
	P7: Commercialisation of technologies via Technology broker	3ª	3ª	4ª
	P8: Development of new business from Corporate Venturing	1ª	1ª	2ª
	P9: Establishment of non-competitive consortia (innovation networks)	2ª	2ª	1ª
	P10: VOW	3ª	3ª	2ª
Italy				
	P1: Value chain	2ª	2ª	3ª
	P2: Product development through patent licensing	3ª	3ª	4ª
	P3: Partnerships for co-development	1ª	1ª	1ª
	P4: Relationship between companies and scientific and technological system	1ª	1ª	1ª
	P5: Spin-offs	1ª	1ª	1ª
	P6: Mergers and acquisitions	4ª	4ª	5ª
	P7: Commercialisation of technologies via Technology broker	3ª	3ª	4ª
	P8: Development of new business from Corporate Venturing	1ª	1ª	2ª
	P9: Establishment of non-competitive consortia	1ª	1ª	2ª

(innovation networks)			
P10: VOW	2ª	2ª	3ª

The results referenced by the Promethee II and Compromise Programming methods reflect the preference, according to the experts, for P4: Relationship between business incubators and scientific and technological system; P5: Spin-offs; P8: Development of new business from Corporate Venturing. The essence of the practices of open innovation is the accumulation of knowledge over time.

Chile: The business incubators in Chile are supported primarily by a coalition of government and universities (Chandra & Medrano Silva, 2012; Chandra & Narczewska, 2009): The Government promotes the national initiative of innovation and R&D; generates jobs, incomes and taxes; promotes regional development; forms partnerships with industry and universities; creates dialogue between key stakeholder groups (Chandra & Medrano Silva, 2012; Chandra & Narczewska, 2009). The Universities helps commercialise academic research; utilises faculty and students; provides experiential learning opportunities; engages with business and community; promotes networking with other universities and promotes community engagement. Finally, the business provides access to innovative ideas and creative people; develops opportunities for acquisitions/joint ventures and provides good marketing and community engagement (Chandra & Medrano Silva, 2012).

Israel: The Israeli innovation incubators programme was adapted from the experience of other countries, mainly the US. As implemented, the programme has shown a strong specificity and homogeneity, both in its content and its rules of implementation. During the last decade, the Israeli high-tech industry has rapidly expanded, with one of the highest rates of startups in the world. High-tech is the major driver of the Israeli economy, emphasised by a growth rate which is the highest of all Israeli industrial sectors. Israel's relative advantage resides in its high human capital, high investments in R&D and high quality of management systems, including its human resources management. Multiculturalism at the workplace has been a real challenge for managers (Jacob Weisberg, 2010). In this perspective, the collection of startups in incubators does provide an unstructured collaboration of people that are in similar situations. It is this collaboration that helps form a perspective of encouragement, networking and information collection and sharing. This incubator environment encourages these activities by creating potential for success (Zablocki, 2007).

Italy: The Italian incubators were originated in the 1980s by the initiative of the public sector in order to promote entrepreneurship and economic development, especially in economically disadvantaged areas of the country. In particular, the Society for the Entrepreneurial Promotion and Development (SPI), from the public sector, played a significant role in the creation of the first business incubators in the form of the BIC, oriented to the model proposed by the European Commission and mainly specialised in high-tech production areas (Astolfi, 2014). In the late 1980s, the Science and Technology Parks also began to implement the ways of creation of incubation in order to support the development of innovative companies. At the end of the 1990s, the Italian university incubators began to spread. The most of the incubators are the result of public intervention, particularly by local authorities and regional development agencies and that indicates a prevalence of their non-profit character (Corsi and Di Berardino, 2014). In Italy, the presence of universities in incubators is significant; this leads to consider universities as a preferential tool for technology transfer from public research to the market. In fact, the universities are as local entrepreneurship catalysts, profiting from the connections established with the companies located in that territory, which stimulate the presence of corporate incubators in order to start knowledge spill-over processes involving universities, incubated startups and the local area (Corsi & Di Berardino, 2014).

Finally, here the open innovation practices and knowledge absorptive capacity are two concepts based on the idea that incubators can leverage the knowledge generated externally to improve their business performance. Open innovation is expressed in terms of the external search breadth and depth strategies, and knowledge absorptive capacity is described by distinguishing between potential

and realised knowledge absorptive capacity (Flor, Cooper & Oltra, 2017). Knowledge is a strategic resource that needs to be managed. The incubators with superior knowledge capabilities are more likely to have a more sustainable advantage. Incubators can continuously search and integrate different types of internal and external knowledge to create new knowledge to provide better products and/or serve their customers better. Incubators that search widely from among multiple sources are better at creating new knowledge, because they increase their knowledge diversity and potentially create more new combinations of knowledge. R&D alliances should be regarded as a complement to rather than a substitute for a firm's internal R&D. On the other hand, spin-offs need a blending capability to balance between (1) market and technical knowledge, (2) market-pull and technology-push approaches, (3) the involvement of customers and parent research centres and (4) potential and realised absorptive capacities (Scaringella, Miles & Truong, 2017). The universities spin-offs are included among the best entrepreneurial initiatives that offer effective and gainful ways for the dissemination of new technologies and innovation (Berbegal-Mirabent, Ribeiro-Soriano & Garcia, 2015; Rodriguez-Gulias, Rodeiro-Pazos & Fernandez-Lopez, 2015; 2016). Several studies (Iacobucci & Micozzi, 2015; Kenney & Patton, 2011) have emphasised that the creation and dissemination of knowledge by universities should be incorporated among the key driving forces for social and economic development (Muller, Fujiwara & Herstatt, 2004). The creation of spin-off firms constitutes a central tool for the commercialisation of the knowledge/technologies therein generated and, therefore, sustaining innovative activities in these business incubators (Corsi & Prencipe, 2017).

Phase 2: Modelling of the optimal effectiveness rate of global performance of business incubators in the light of the influence of the practices of open innovation in the knowledge absorptive capacity.

This phase focuses on determining the optimal efficiency rate (OERVC) for global performance of business incubators in the Chile, Israel and Italy using Neurofuzzy modelling. It is a process whose attributes usually possess high subjectivity characteristics, in which the experience of the decision maker is very significant. Thus, within this spectrum, there is the need for a tool that allows adding quantitative and qualitative variables that converge towards a single evaluation parameter (Cury & Oliveira, 1999; von Altrock, 1997). This model combines the Neural Networks and Logic Fuzzy technology (neurofuzzy technology). Here, this model supports the planning of the practices of open innovation on the knowledge, knowledge absorptive capacity and business incubators performance (global), as it allows to evaluate the desirable rate toward the acceptable performance of incubators. The model shown here uses the model of Cury and Oliveira (1999). Based on the neurofuzzy technology, the qualitative input data are grouped to determine the comparison parameters between the alternatives. The technique is structured by combining all attributes (qualitative and quantitative variables) in inference blocks (IB) that use fuzzy-based rules and linguistic expressions, so that the preference for each alternative priority decision of the optimal rate of outcomes performance determinants, in terms of benefits to the incubators, can be expressed by a range varying from 0 to 10. The model consists of qualitative and quantitative variables, based on information from the experts. The neurofuzzy model is described below.

Determination of input variables (IVs): This section focuses on determining the qualitative and quantitative IVs.

These variables were extracted (Figure 1: 10 variables: Value chain; Product development through patent licensing; Partnerships for co-development; Relationship between business incubators and scientific and technological system; Spin-offs; Mergers and acquisitions; Commercialisation of technologies via Technology broker; Development of new business from Corporate Venturing; Establishment of non-competitive consortia (innovation networks); and VOW) from the independent variables (dimensions of results Influence the practices of open innovation in the knowledge absorptive capacity in business incubators in the Chile, Israel and Italy). The linguistic terms assigned to each IV are: high, medium and low. Accordingly, Table 1 shows the IVs in the model, which are transformed into linguistic variables with their respective Degrees of Conviction or Certainty (DoC),

with the assistance of 20 judges opining in the process. The degrees attributed by the judges are converted into linguistic expressions with their respective DoCs, based on fuzzy sets and IT rules (aggregation rules), next (composition rules).

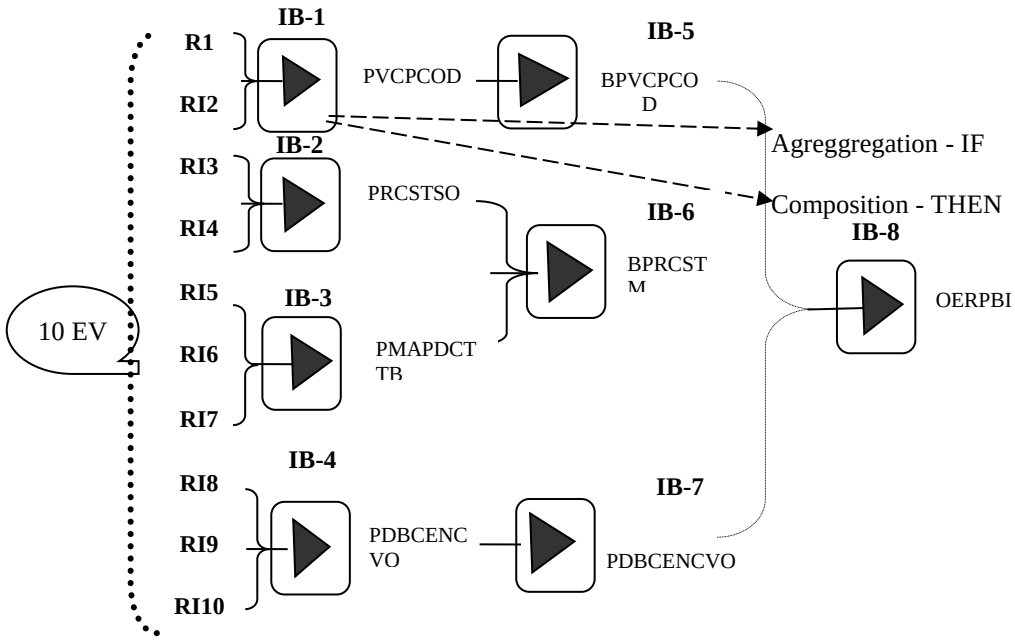

Figure 2: Neurofuzzy model

Determination of intermediate variables (IVars) and linguistic terms: The qualitative IVs go through the inference fuzzy process, resulting in linguistic terms of IVars. Thus, the linguistic terms assigned to IVar are: low, medium and high. The IVars were obtained from: Performance of the value chain and partnerships for co-development: PVCPCOD; Performance of relationship between business incubators and scientific and technological system and Spin-offs: PRCSTSO: Performance of mergers and acquisitions, product development through patent licensing and commercialisation of technologies via Technology broker: PMAPDCTTB; Performance of development of new business from corporate venturing, establishment of non-competitive: DNBENC consortia (innovation networks); and Performance of VOW): PDBCENCVO.

The architecture proposed is composed of eight expert fuzzy system configurations, four qualitative IVs that go through the fuzzy process and through the inference block, thus producing an output variable (OV), called IVar. Then, the IVars, which join the other IVar variables form a set of new IVars, thereby configuring a sequence until the last layer in the network. In the last layer of the network, the OV of the Neurofuzzy Network is defined. This OV is then subjected to a defuzzification process to achieve the final result: Optimal Efficiency Rate of Business Performance in Chile, Israel and Italy. In summary, the fuzzy inference occurs from the base rules, generating the linguistic vector of the OV, obtained through the aggregation and composition steps. For example, when the experts' opinion was requested on the optimal efficiency rate for the business performance in incubator A, the response was 8.0. Then, the fuzzification (simulation) process was carried out, assigning low, medium and high linguistic terms to the assessment degrees at 1–10 scales. Degree 8, considered low by 0% of the experts, medium by 55% and high by 45% of the experts. In summary, the expert's response enabled to determine the degree of certainty of the linguistic terms of each of the IVs using the fuzzy sets.

The results confirm the H2: The optimal rate of global innovation performance depends on the combination and interaction of the influence of the practices of open innovation in the knowledge absorptive capacity in business incubators from Chile, Israel and Italy. The generic fuzzy sets were defined for all qualitative IVars, which always exhibit three levels of linguistic terms: a lower, a medium and a higher one. After converting all IVars into its corresponding linguistic variables with their respective DoC, the fuzzy IB, composed of If-Then rules, are operated based on the Max–Min operators, obtaining a linguistic value for each IVar and OV of the model, with the linguistic terms previously defined by the judges. With the IVs, the rules are generated. Every rule has an individual weighting factor, called certainty factor (CF), between 0 and 1, which indicates the degree of importance of each rule in the fuzzy rule-base. The fuzzy inference occurs from the rule-base, generating the linguistic vector of OV, obtained through the aggregation and composition steps.

Determination of OV—optimal efficiency rate of business incubators performance: The OV of the neurofuzzy model proposed was called optimal efficiency rate of business performance in the incubators. The fuzzification process determines the pertinence functions for each IV. If the input data values are accurate, results from measurements or observations, it is necessary to structure the fuzzy sets for the IVs, which is the fuzzification process. If the IVs are obtained in linguistic values, the fuzzification process is not necessary.

Fuzzy Inference: The fuzzy inference rule-base consists of If-Then rules, which are responsible for aggregating the IVs and generating the OVs in linguistic terms, with their respective pertinence functions. According to Von Altrock (1997), a weighting factor is assigned to each rule that reflects their importance in the rule-base. This coefficient is called CF, and can vary in range [0, 1] and is multiplied by the result of the aggregation (IT part of inference). The fuzzy inference is structured by two components: (1) aggregation, i.e., computing the IF rules part and (2) composition, the Then part of the rules.

Defuzzification: For the applications involving qualitative variables, as is the case in question, a numerical value is required as a result of the system, called defuzzification. Thus, after the fuzzy inference, fuzzification is necessary, i.e., transform linguistic values into numerical values, from their pertinence functions (Von Altrock, 1997). The IT Maximum Centre method was popularised to determine an accurate value for the linguistic vector of OV. Based on this method, the degree of certainty of linguistic terms is defined as 'weights' associated with each of these values. The exact value of commitment is determined by considering the weights with respect to the typical values (the maximum values of the pertinence functions) (Cury & Oliveira, 1999; Von Altrock, 1997).

By the way of demonstration, using assigned IT (average) hypothetical (Incubator A) enters-IT into the calculation expression of TPCITj with GdCi of the following linguistic vector of the OV, also hypothetical: Low = 0.20, Middle = 0.53, High = 0.17. The numerical value of OERVC at a 0–1 scale corresponds to 0.9417, resulting from the arithmetic mean of the values resulting from the defuzzification of each of the simulated 20 judges. This value corresponds to an average value for OERP. With this result (optimal efficiency rate: 0.9417) produced, it is feasible to assert that this combination of open innovation practices of business incubators can at least ensure the performance desired by the firm at that time. It is plausible that the incubator maintains at least this value (0.9417), which ensures the desired performance. To illustrate this, assuming that the study-object incubators demonstrate the following optimal efficiency rates for business performance of incubators: Israel: 0.8892; Chile: 0.7891; Italy: 0.7628. The expected reference performance for all incubators (three countries) is 0.6827 (hypothetical) (Figure 3). It is concluded that:

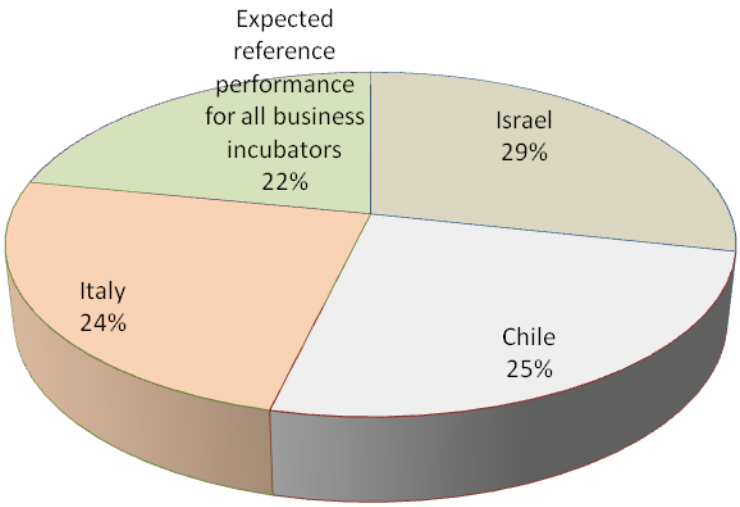

Figure 3. Optimal efficiency rate of business performance of incubators from Chile, Israel and Italy

Israeli business incubators show efficiency (best performance) in the combination of their practices of open innovation based on the knowledge absorptive performance (29%). The priorities of the practices of open innovation for performance of business incubators in the three countries are dynamic and dependent on constraints and uncertainties that come from the environment at any given time. Incubators in Chile, Israel and Italy also are efficient in combining their strategies of practices of open innovation for knowledge absorptive capacity and business performance, since they do meet the desired performance expectations (22%). The environmental contingencies are crucial and essential to adapt the strategies. Necessary knowledge relevant to accomplish activities largely resides beyond a firm's boundaries (Lakhani & Panetta, 2007). Thus, it is important look to the practices of Open innovation in the knowledge absorptive capacity and business performance in the incubators in the three countries. The knowledge is the recipient for success of open innovation. This leads us towards a long-ignored knowledge (and sources of knowledge) lens on both innovation and business performance in the Chile, Israel and Italy.

5. Conclusions and limitations

This research aims to verify the relationship between the open innovation practices and knowledge absorptive capacity in business incubators performance from Chile, Israel and Italy. Furthermore, this research examines how this affects the outcomes (business incubators performance). The study attempted to cover an existing space in the literature about the relationship between open innovation practices, knowledge absorptive capacity and business performance from business incubators in the three countries.

Knowledge of R&D (knowledge from R&D sources) is crucial for practices of open innovation. It confirms the state of the art. Shanklin and Ryans (1984) suggest that incubators anticipate potential technical and scientific capabilities that provide quick responses to the existing techniques, enabling to meet the market demands to be constructed or altered. It is reasonable to focus efforts on knowledge of R&D, thereby creating an internal stock of scientific knowledge (Feinberg & Majumdar, 2001; Griliches, 1979), which enables to develop and introduce new products, lower production costs, more competitive prices and greater financial return (Kafouros, 2008a; 2008b). Knowledge of R&D has indirect effects on increasing the organisational learning, enables to understand external ideas and technologies and apply them to the ultimate business outcome (Cohen & Levinthal, 1989) and also contributes to identifying areas that are still technologically unexplored (Miller, Samambaia & Cardinal, 2007). This logic will be maintained, however, only through opening spaces for the various

(open innovation practices) strata: Universities and Research Centres; partners, spin-offs, suppliers and customers. Nevertheless, the practices of open innovation will have to be anchored in efficient planning policies.

This research contributes to the theory and practice of innovation management in business incubators. Such contribution can elaborate into: at practical level, it is expected that this study will provide evidence of business incubators role in managing innovation and social interaction in three countries and it also contributes as guidance on how to adopt absorptive capacity in order to improve competitiveness in globalised business environment. At the theoretical level, this study aims to enrich the literature of business incubator. Finally, at the policy level, this research enables to contribute to important policy to increase the welfare of the three countries.

In the research, the cross-sectional data used in this study may not be appropriate to establish fundamental relationships between variables, but as referenced by Kenny (1979), the relationships that use cross sections are satisfactory and popularly accepted in relationship tests. Furthermore, a survey was developed for incubators in Chile, Israel and Italy in a static context, which may represent a limiting factor. Therefore, it is recommended to reproduce and replicate the model in incubators from other countries in order to confirm the results. It is also recommended that the practices of open innovation dimensions should be extracted from the state of the art, but strongly confirmed by the state of practice, by the judgment of other experts (from other countries), taking into account that values, beliefs, cultures and experiences are determinants in the assessment, which can overturn the effects on the results.

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