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Key settings for successful Open Innovation Arena ☆

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ABSTRACT

The purpose of this paper is to examine settings for the Open Innovation Arena. In greater depth, this paper aims to analyse and reveal which factors influence the formation of an appropriate arena for doing open innovation and furthermore to prescribe how a firm can create an effective arena to gain access to external knowledge. This paper presents a review on open innovation literature with the purpose of examining the current understanding of factors influencing a firm's capacity to embrace and practice open innovation as well as understanding what is critical when fitting outside systems. It presents the results of a survey conducted among 25 researchers from INESC TEC, the Portuguese Institute for Systems and Computer Engineering, Technology, and Science. The study concludes that conditions, namely culture, leadership and strategy, are the main drivers to an open innovation arena, highlighting culture as the most important one.

1. Introduction

In today's highly competitive environment, the goal of each organisation is to conquest competition and to win new customers. Individuals who are holders of knowledge represent a tool for the generation of innovations. Thanks to their personal creativity, knowledge, skills and abilities it is possible to generate new innovative ideas that will help organisations to achieve a competitive advantage. Business success in developed economies and markets depends on the technological progress and technological innovation resulting from this same process. The term "innovation" is widely accepted by industry and academic professionals as an essential competitive enabler for any enterprise seeking to sustain growth. Innovation is viewed as the main driver for companies to prosper, grow and sustain their profiles (Hungund & Kiran, 2015). The present study was developed at INESC TEC, The Portuguese Institute for Systems and Computer Engineering, Technology and Science, the host Institution where researchers carried out their investigation. Researchers decided to choose INESC TEC's environment to study, as INESC TEC is a Research Centre well positioned when compared to similar national and international R&D Centers, has good resources (Human, Financial and Material) and has good image among society, researchers, collaborators and other stakeholders. Open Innovation demands, among others, qualification, talent, success, leadership, prestige and freedom to experiment, be creative and think out of the box. INESC TEC seems to gather all these assumptions.

The purpose of this paper is to examine settings for the Open Innovation arena, suited for the analysis and improvement of INESC TEC. More particularly, the paper looks at how a firm can generate the conditions required to benefit from outside performers' knowledge at the crossing point between the firm's boundary and the outside world. This process requires creating a"place" which will encourage collaboration and allow the firm to use remotely accessible information in a compelling manner. Such "place" is translated into open Innovation arena, through physical locations (e.g., Chesbrough, 2003; Hungund & Kiran, 2015), community of practices (e.g., Lave & Wenger, 1991), sociotechnical practices (e.g., Henderson, 1999), arena (e.g., Elkjaer, 2004), sociomateriality practice (e.g., Orlikowski, 2007), cross-boundary teaming (e.g., Edmondson & Harvey, 2017), etc. The structure of this work is divided into five sections: Section 1 is introduction; Section 2 presents a literature review concerning the approaches to the open innovation arena; Section 3 deals with the methodology used in the development of this study and describes the work developed at INESC TEC; Section 4 presents the survey results and, finally, Section 5 presents the conclusion and suggestions for future research.

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2. Literature review

Innovation is a complex and multi-factorial challenge. It is commonly accepted that innovation is vital to economic growth, to the formation of new industries and to the tackling of societal challenges. An increased understanding of the factors (at the level of the firm, region or state), is the focus of much research, policy and practice (European Commission, 2014). The relations among the elements in a company's environment, influence the predisposition to innovate, verifying that innovation leads to stronger competitive advantages when the elements of the macro-environment of the activities of the companies are well articulated in the form of a system instead of each element working mainly isolated (Rivotti, 2015). When this is verified, innovation is also more frequent and better managed (Dodgson, Gann, & Salter, 2008). This is especially important in small countries and small companies whose resources are scarce to nurture R&D.

2.1. The term innovation

Innovation is the implementation of a new or significantly improved product (good or service), process, a new marketing method, or a new organizational approach in business practices, workplace organization or external relations (Manual, 2005). However, it is important to distinguish between invention and innovation, as 'innovation' is actually the introduction on the market of a new product, process or system, whereas 'invention' is only its discovery and creation (Marques, 2014). Innovation advances through the innovative effort that is developed within society and the economy, where all kind of actors may act, namely firms, government, non-profit institutions or universities (Caraça, Lundvall, & Mendonça, 2009). Innovation defines its four types as: product/service, process, marketing and organizational (Table 1).

Nowadays, new business models are also an important type of innovation models, as it requires imagination and courage. Implementing old, tried and true strategies in a time of dramatic change rarely work (Nussbaum, 2005).

Innovation results from an idiosyncratic and unpredictable chain of action and feedbacks, namely (i) Firm's well tried, tested and trusted business routines; (ii) Efforts to deviate from its own track record and (iii) Signals and responses of its relevant techno-economic environment (Caraça, Ferreira, & Mendonça, 2007) and sociotechnical arena (Jorgensen & Sorensen, 1999).

"Everyone knows that innovation is a core business necessity and Companies that don't innovate, die" (Chesbrough, 2006). Innovation is crucial to survive, but innovation management depends critically from Creating interfaces and Managing them. These interfaces accordingly to (Caraça et al., 2007) are formed and explained by: Technological awareness, Technological cooperation, Technological scanning, monitoring and forecasting, New users, Weak signal analysis, Intellectual property, Internal creativity, Innovation-friendly governance, Organisational capabilities and Knowledge management.

Table 1
Types of innovation (Manual, 2005).

Innovation	Content
Product/ Service	• Good or service that is new or significantly improved relatively to its initial characteristics or intended use • Significant improvements in technical specifications, components and materials, incorporated software, user friendliness or another functional characteristic • Use of new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies
Process	• Implementation of a new or significantly improved production or delivery method • Significant changes in techniques, equipment and/or software • Intended to decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products
Marketing	• Implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion • Addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales
Organizational	• Implementation of a new organizational method in the firm's business practices, workplace organization or external relations • Intended to increase a firm's performance by reducing administrative costs or transaction costs, improving workplace satisfaction (and thus labour productivity), gaining access to non-tradable assets (such as non-codified external knowledge) or reducing costs of supplies

2.2. The open innovation paradigm

Innovations are a key source of a competitive advantage that determines the economic success of each organisation. This means that a specific innovation can no longer be seen as the result of predefined and isolated innovation activities but rather as the outcome of a complex co-creation process, involving knowledge flows across the entire economic and social environment. Opening up the innovation process to all active players is the basic premise of open innovation: knowledge can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship (European Commission, 2016).

Open innovation has been proposed as a new paradigm for the management of innovation (Chesbrough, 2003) and can be defined as "A paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology".

Fig. 1 shows the closed paradigm for managing industrial R&D, where projects start on the left, at the beginning, and proceed through within the firm untill they are shipped to customers on the right side.

Conversely, the open innovation paradigm assumes that businesses can and should use external ideas as well as internal ideas, and internal and external paths to market. Companies doing research and development alone, fail to productively make use of new knowledge and ideas outside their business. Open innovation combines both external and internal ideas to create value. In addition, ideas can be taken to market through external channels,

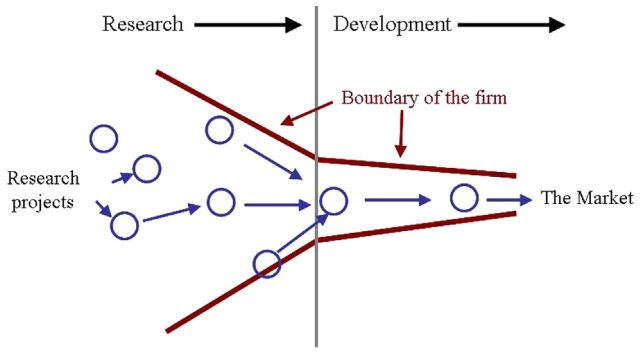

Fig. 1. Closed innovation paradigm for managing industrial R&D (Chesbrough, 2006).

outside the current business of the firm, to generate additional value, as can be seen in Fig. 2.

In fact, open innovation is much broader and enables organisations to drive in a new way. A way that empowers co-workers, community members, stakeholders, and fans to tackle challenges and improve the organisation. In open innovation, organisations need to utilise both internal and external resources.

Open innovation has several facets (Randhawa, Wilden, & Hohberger, 2016) and it is a multi-level occurence (Bogers et al., 2017), generating major gaps on how such innovation is integrated (West & Bogers, 2014). It is a dynamic process and so the research needs to incorporate dynamic elements (Appleyard & Chesbrough, 2016).

In fact, innovation openness can involve several features, such as partner and feature training, risk, exchange and share, belief and governance (Kratzer, Meissner, & Rould, 2017). Moreover, it is essential to understand the structures and processes that facilitate open innovation at the organizational level (Bogers et al., 2017), knowledge management strategies (Cammarano, Caputo, Lamberti, & Michelino, 2017), as well as its human side (Ahn, Minshall, & Mortara, 2017).

Open innovation has risen to the fore of becoming one of the most significant topics in innovation management. It constitutes a worldwide phenomenon, where people share ideas and work together through open and transparent networks for commercial or social purposes (Huizingh, 2011). Opening up the innovation process to all active players is the basic premise of open innovation: knowledge can circulate more freely and be transformed into products and services that create new markets, fostering a stronger culture of entrepreneurship (European Commission, 2016).

Accordingly to Lopes and Carvalho (2018: 284), the existing literature on open innovation is not satisfactorily theorized (Bogers et al., 2017; Gambardella & Panico, 2014), researchers do not adequately draw on theoretical perspectives (Randhawa et al., 2016) and it is mainly descriptive by nature (Martinez-Conesa, Soto-Avosta, & Carayannis, 2017).

Innovation is the result of a chain of interactions between an innovative company's nuclear skills and the skills of the agents in their economic environment (Caraça, 2010). Suppliers, financiers, consultants, partners, customers and competitors are actors in the system in which the core competences of the company interact and learn (through interfaces) and provide the essential framework of relationships for the company's innovative activities and networks of cooperation and competition, in the global economy of knowledge (Caraça, Lundvall, & Mendonça, 2008). As a result, innovation does not follow a linear path. There is sharing, transfer and feedback of information between complementary stages throughout the process. Innovation can emerge from three fields of knowledge: scientific and technological research; business methods research; market research and design. The company assumes a central position, with its core departments arranged in a similar hierarchical position, so innovation can be originated anywhere. Between the centre and the existing areas of knowledge are interfaces for knowledge interpretation, emphasising that the inventiveness of the company rests at the centre (Caraça et al., 2008).

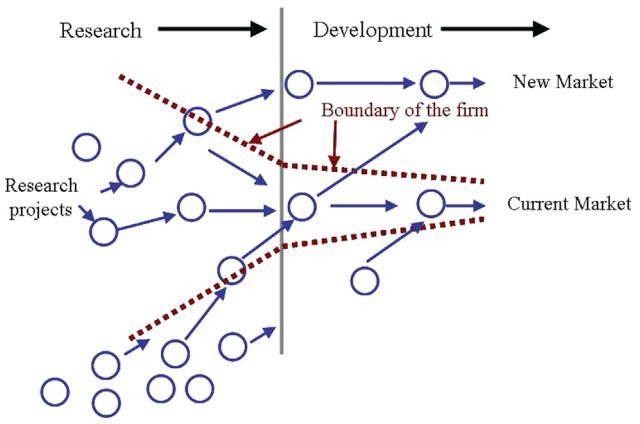

Fig. 2. Open innovation paradigm for managing industrial R&D (Chesbrough, 2006).

2.3. Open innovation arena

An open innovation arena may be described as an actor trying to enable open innovation within a specific field of expertise while, at the same time, seeing himself as a key player in the field (Aspenberg & Kumlin, 2012). National Innovation Systems (NIS) is defined as a network of institutions in the public and private sectors, whose activities and interactions initiate, import, and diffuse modern technologies (David & Garry, 2010). Therefore, the institutions and the actors which perform within the system should also be viewed in a dynamic perspective. This is enabled by the Triple-Helix model with the three interactions between government – university, university – industry and government – industry (Leydesdorff & Etzkowitz, 1996). The NIS describes the intersection of industry with research and development, which is undertaken by many parties and players. This interaction is affected by the availability of skilled labour (education and training policies), and incentive mechanisms provided by government (Intellectual Property Rights-IPR, tariffs, subsidies, taxation, etc.) (Savitskaya, 2011). A broader perspective considers that the social, cultural, and political environments are embedded within the narrower concept of the NIS (Godin, 2010). Furthermore, Lundvall (2007) it points out two approaches: the core and the context. Innovation can be considered from the perspective of within the firm (core), as well as from the external point of view (context/environment). The concepts can be treated at various levels, and are expressed by cultural values, processes and practices or artefacts (Hallbrant & Ingvarsson, 2012). In open innovation literature, culture is seen as highly interrelated with practices and artifacts and none of them can be isolated. The empirical findings has shown that culture can be seen as a result of practices and artifacts but the opposite can also be true, i.e. that the culture influences the practices and artifacts as when the cultural change is viral and subsequently changes how the organization works (Hallbrant & Ingvarsson, 2012). In order to make the Triple-Helix approach working, absorptive and desorptive capacity should also be considered. The former constitutes a pre-condition for inbound open innovation (Spithovena, Clarysse, & Knockaert, 2010) whereas the latter deals with the ability to identify opportunities in which knowledge can be explored externally and subsequently acted upon (Gassmann & Enkel, 2004). National Culture concerns the differences in values held by groups of nations and/or regions. Since almost all human beings simultaneously belong to a set of diverse groups, people carry several layers of mental programming within themselves, which correspond to various levels of culture (Hofstede, 1991). In addition to the challenges of finding, evaluating, negotiating, transferring and integrating external technology into their own products, companies are confronted with internal resistance to external innovations. This resistance is known as the "Not Invented Here" syndrome (Chesbrough, 2003; Van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009). The perspective of practices is extended to include internal procedures and structures as they connect with internal and external levels. These are denominated artefacts, a term covering practices but which includes organizational procedures and auxiliary components that depict how the organization operates (Schein, 2004). Developing a specific type of modern technology or product is inherently risky, so that

an open approach to innovation is associated with greater uncertainty than a closed approach (Herzog & Leker, 2010). Top management is a key factor in overcoming resistance from those who challenge the introduction of open innovation. According to (Chiaroni, Chiesa, & Frattini, 2011), the role of top management in the early and mid-stages constitutes a pre-requisite for the implementation of open innovation, commitment, being the support from top management essential. Two ideas in this study are particularly noteworthy: Organizational risk-taking and Management support. When the term "absorptive capacity" was coined by Cohen and Levinthal (1990), they defined it as a firm's ability to recognize the value of additional information, subsequently assimilating it, and applying it to the firm's commercial purposes. Desorptive capacity could be considered simply as the reverse: the ability to release knowledge toward a recipient that is able to transform it into a commercial output, either immediately or in the short term. Absorptive/Desorptive Capacity are both influenced by the degree of motivation involved – the ability to transfer and/or learn and use – which the actors on both sides of the knowledge domains (university to industry) attribute to the transfer process (Minbaeva, Pedersen, Bjorkman, Fey, & Park, 2003).

2.4. Innovation modes

Diverse procedural approaches have been applied in the identification of distinct modes of innovation (Nunes, Lopes, & Dias, 2014). Nevertheless, knowledge and learning are always present, and their linkages define the different modes of innovation used by firms. Jensen, Johnson, Lorenz, and Lundvall (2007) suggest two different modes of learning and innovation: the one based on the production and use of codified scientific and technological knowledge (S&T), and the one based on learning from experience and supported by interactive learning processes (DUI). Lundvall (2007) and Jensen et al. (2007) highlight the role of knowledge in the innovation process, recognizing the importance of collective learning processes in knowledge production. Innovation occurs in all sectors and the knowledge pertinent for innovation derives not only from the traditional scientific system, but also from the collective learning processes associated with various contexts and the formal and informal interaction of the various actors in them (Nunes, 2012) (Nunes & Lopes, 2012). As (Hudson, 1999) stresses "The emphasis now is therefore upon recognizing that innovation is an interactive process that involves the synthesis of different types of knowledge rather than privileging the formal scientific knowledge of the R&D laboratory over other forms of knowledge" and "creating dense horizontal flows of knowledge and information within, vertical flows of knowledge, and information between the various functional divisions of the company, while opening the ears of those involved within the company to voices from outside its boundaries" (op. cit: ibid). For S&T mode, innovation in firms is the result of investments in R&D and S&T, and interaction with centres producing new knowledge, which produce the codified and explicit knowledge which can be used by the firm to produce new innovations. The capacity to generate and adopt new innovations will also be largely dependent on the human capital available in the firm and on the level of training of employees (Rodríguez-Pose & Crescenzi, 2008).

For DUI mode, innovation in the firm is mostly generated by the capacity of managers and employees to find solutions to concrete problems and accept the challenges proposed by suppliers, customers, and the market. Innovation is therefore about markets and organisations (Caraça et al., 2009), and the result of a combination of learning-by-doing and using, which requires a huge amount of mainly informal interaction between people, both within and outside the firm (Barge-Gil, Jesús Nieto, & Santamaría, 2011; Lundvall, 1992; Storper & Venables, 2004). Constant and repeated interaction generates the tacit knowledge which facilitates the response to user demands and, ultimately, drives innovation within the firm (Jensen et al., 2007). Litterature shows that firms which engage in collaboration with external agents tend to be more innovative than firms that rely on their own resources for innovation (Fitjar & Rodríguez-Pose, 2013). While interaction with suppliers tends to promote greater levels of product and process innovation, both of the incremental and radical type, and interaction with customers is particularly beneficial for product innovation, collaboration with competitors has a detrimental effect on the propensity of firms to innovate and partnerships within the same conglomerate only matter for incremental product innovation. Firms which have established links with extra-regional universities, research centres and consultancies and, in particular, with suppliers and customers outside the region have seen their innovation potential increase radically in virtually all types of innovation. Firms are more likely to innovate when they purposely look for partners which may provide knowledge that can then be easily transformed into new ideas (Fitjar & Rodríguez-Pose, 2013).

3. Methodology

The methodology and the methods selection were developed around the main aims of the study. The present research has been done during 2017 and was conducted on INESC-TEC. INESC TEC is a private non-profit research institution, dedicated to scientific research and technological development, technology transfer, advanced consulting and training, and pre-incubation of new technology-based companies. As an institution operating at the interface of the academic and business worlds, bringing closer together academia, companies, public administration, and society, INESC TEC typically applies the knowledge and results generated as part of its research in technology transfer projects, seeking value creation and immediate social relevance. Present in six sites in the cities of Porto, Braga and Vila Real, INESC TEC incorporates thirteen R&D Centres, structured in four thematic domains - Computer Science, Industry and Innovation, Networked Intelligent Systems, and Power and Energy. INESC TEC hosts over 700 integrated researchers (about 350 PhDs), including staff researchers, researchers from Higher Education Institutions, grant holders and affiliated researchers. INESC TEC's team also includes trainees, and technical and administrative support staff. The mission of INESC TEC is to achieve advancement in science and technology and to enable science-based innovation through the transfer of new knowledge and technologies to industry, services and public administration. INESC TEC vision is to be a leading Science and Technology Institution at international level, perceived as an important world player, in the domains of Computer Science, Industry and Innovation, Networked Intelligent Systems, and Power and Energy. Excellence, ambition, accuracy and exigency are its values. It got an official evaluation of excellent, in 2014, by FCT (Fundação para a Ciência e Tecnologia - Foundation for Science and Technology, sponsored by the Portuguese Government).

A written questionnaire was distributed, with 24 questions. The questionnaire was adapted from Innovation Scoring questionnaire and was conducted among twenty-five researchers from INESC-TEC. The interviewed had different academic background and the questionnaire's logic had been explained before presenting it to them. Data were collected by hand and analysed with critical thinking.

In this research, there were five main stages: literature review, interviews, data collection, data treatment and conclusion. In the first stage, the work discusses Open Innovation and its activities, as well as the difference between open and closed innovation. This stage also includes key literature, such as the factors affecting Open

innovation, its concepts and practices. In the second stage, the study presents the interviews conducted among researchers at INESC TEC. The Interviews were based on a questionnaire model developed through "Innovation Scoring", which was distributed to researchers from INESC-TEC, getting twenty-five answers.

In the third stage, the data was treated and the work discusses the results, which are displayed in graphic form. Data treatement was quantitative and qualitative. However, it was predominantly qualitative as the questionnaire considered the Perceptions of participants themselves (the human factor) to measure the results.

A detailed analysis is subsequently undertaken in the the fourth stage and finally stage five presents the conclusion and provides proposals for future work.

3.1. Settings for the open innovation arena

The world is being subjected to constant change and there are now many tools at hand to evaluate innovation processes in organizations. In the case of this study, it was used the innovation scoring model developed in Portugal by IAPMEI (the Portuguese Agency for SME and Innovation) and COTEC Portugal (the Business Association for Innovation). Using this system, the organizations will be able to adequately diagnose, measure and question their innovation performance and potential, which is of undeniable value for the organizations that will lead our country's economic future - that is, those which are more aware of the issues of competitiveness in a knowledge-based global economy. The Innovation Scoring System has four basic dimensions - Conditions, Resources, Processes and Results - and thirteen subgroups, with a total of forty-three issues. To respond to the questions of the first three dimensions (Conditions, Resources and Processes) a distinction is made between: (i) the approach, that is, the manner in which the organization deals with each theme and its perspective before the various corresponding topics; and (ii) the deployment, that is, the manner in which the organization really acts in relation to the considered topics. To respond to the questions of the last dimension (Results), a double assessment is not necessary, since the nature of this dimension requires an answer that agrees with the results actually achieved on each parameter of analysis.

Conditions dimension section relates to environmental and strategic aspects that might influence business attitudes and behaviour in comparison with innovation. Three aspects are considered: Culture, where it is intended to reflect the adequacy between the company's culture and dynamics of change inherent to innovation; Leadership, seeking to assess how leadership characteristics and style can stimulate innovation; and Strategy, related to definition and implementation of the organization's strategic orientations. Attention must be paid to the fact that the extent of involvement at various levels of the organization (functional, hierarchical, among others) should be taken into account when assigning the scores.

Resources dimension purpose is to assess the contribution of various types of organization resources in order to secure greater dynamics and a better innovative performance. There are multiple types of organizational resources. In this tool, four types of resources are to be considered: Human Capital, where the purpose is to assess the way the management of human resources of the organization is guided by innovation. Organizational Competencies, corresponding to the analysis of the relevant competencies and capabilities to raise its innovative performance and subsequently, its competitive affirmation; External Relations, seeking to examine the manner in which the company uses its external connections, more specifically the cooperation with other entities in order to stimulate innovation; and Organizational Structures of support to the innovation activities.

The purpose of Processes dimension is to analyse the more relevant organizational processes for the new innovative dynamics of the organization and the performance of these in the innovation domain. Three groups of processes are considered: Management of RDI activities, including various facets of development of this type of activities, namely innovation project management, market interpretation, the design and development of new products and/or services, interdepartmental cooperation, establishment of project teams, the assessment of innovation activities and the desire to innovate in all activities of the value chain; Learning and systematic improvement, concerning the implementation of obtained learning and the implementation of good practices; and Protection and Assessment of the results of RDI activities. However development of RDI activities is not a goal in itself, but rather a tool for the attaining of the purposes that are generally defined for the organization, taking particular account to the interests of its stakeholders and sustainability. Resources dimension seeks to analyse to what extent conditions, resources and processes geared at innovation translate into results that are measurable, as far as possible. The results are considered from three points of view: Financial, reflecting the contribution of innovation to profitability; Market, including the effects in terms of market share, sales of new products/services, image, prestige and impact on the activity sector; and Society, namely creating qualified jobs.

Innovation Scoring aims to contribute to the strategic reflection of companies or other organizations regarding their innovation processes, enabling not only a deeper knowledge of the different dimensions that sustain such processes, but also the identification of Areas of potential improvement. The first version of the Innovation Scoring System was developed by COTEC in 2007 (Cotec, 2009). In 2008, it became accessible online, through a platform available to companies. Since its launch, this platform has been systematically used by approximately 700 companies in Portugal, which have used it to evaluate their innovation performance and to access many of the benefits offered by COTEC and IAPMEI.

4. Survey results

The questionnaire survey was based only on three of the four dimensions worked on Innovation Scoring: Conditions, Resources and Processes. The fourth dimension of Innovation Scoring model is Results and Results means finance, market and society. Researchers decided not to consider this dimension for operational reasons, e.g. enough time to discuss with INESC TEC main partners, namely academia, companies, public administration, and society. As an institution operating at the interface, INESC TEC typically applies the knowledge and results generated as part of its research in technology transfer projects, seeking value creation and immediate social relevance.

For this particular study, a questionnaire was developed to present twenty-four (24) questions. These questions were chosen for being, from the researchers point of view, the easiest to be answered. By means of these questions, one was able to gain a better understanding of the factors required and the difficulties faced when creating an Open Innovation arena. This survey questionnaire was conducted among twenty-five (25) researchers from INESC TEC. Questionnaires were distributed in paper format during two days, in a random order. Questionnaires were collected one week after. Results are presented in Tables 2–4. This questionnaire survey focuses mainly on the following factors:

- Conditions (Culture, Leadership and Strategy);
- Resources (Human Capital, Competencies, External Relations and Structures);

Table 2
Questionnaire survey and results (Dimension – Conditions).

Dimensions	Factors		Questions	Excellent	Integrated	Defined	Reactive	Non-Existent
Conditions	Culture	1	The values of the organization promote adaptability, experimentation, learning and continuous change.	60%	40%	–	–	–
		2	The values of the organization promote international openness.	48%	52%	–	–	–
		3	The internal communication of the organization integrates various perspectives, resorting to formal and informal mechanisms to circulate information and share knowledge.	28%	40%	32%	–	–
		4	The organization's culture stimulates entrepreneurship and the capacity to take risks, without penalizing failures.	24%	48%	28%	–	–
	Leadership	5	Leadership structures promote the appearance of leaders who will develop innovative activities through the responsibility and autonomy of its staff.	20%	40%	32%	8%	–
	Strategy	6	The organization has a clear and shared innovation strategy, engaging staff in its definition.	8%	24%	60%	8%	–
		7	Innovation strategy appears as a plan of action, with quantitative purposes and targets for the medium and long term.	8%	12%	72%	8%	–

Table 3
Questionnaire Survey and Results (Dimension – Resources).

Dimensions	Factors		Questions	Excellent	Integrated	Defined	Reactive	Non-Existent
Resources	Human Capital	8	The organization has a human capital policy to address innovation.	12%	68%	20%	–	–
		9	The organization has a training policy for its staff, oriented towards innovation.	–	44%	20%	32%	4%
		10	The organization stimulates and supports creativity and innovative initiatives from its staff.	8%	48%	16%	28%	–
	Competencies	11	The organization systematically proceeds with the identification, consideration and planning of the development of its organizational competencies.	–	16%	60%	24%	–
		12	The organization possesses adequate technical competencies to perform R&D activities.	20%	20%	52%	8%	–
	External Relations	13	The organization develops systematic cooperation actions on innovation with external entities.	48%	44%	8%	–	–
		14	The organization boosts many ways of networking.	16%	72%	12%	–	–
	Structures	15	The organization has an organizational structure dedicated to R&D activities.	12%	44%	32%	12%	–
		16	The organization possesses adequate structures for the management of knowledge.	4%	56%	20%	16%	4%
		17	The organization has information and communication systems in place to enable innovation.	–	44%	44%	8%	4%

Table 4
Questionnaire survey and results (Dimension – Processes).

Dimensions	Factors		Questions	Excellent	Integrated	Defined	Reactive	Non-Existent
Processes	Management of R&D activities	18	The organization develops systematic processes to understand needs, expectations and market opportunities.	–	40%	32%	28%	–
		19	The organization has adopted systematic processes to generate, identify and select ideas and concepts for new products, processes, services and business and/or organization models.	8%	24%	64%	4%	–
		20	The organization develops systematic processes for inter-departmental cooperation.	8%	20%	68%	4%	–
		21	The organization has well-defined routines to build and define tasks for the project teams.	16%	64%	16%	4%	–
	Systematic learning and improvement	22	The organization incorporates all the learning acquired into its activities.	28%	8%	48%	16%	–
		23	The organization has systematic devices to enable adopting good practices.	12%	44%	32%	12%	–
	Protection and assessment of results	24	The organization has defined processes to evaluate and decide on the protection and assessment of its intellectual capital and R&D results.	8%	52%	40%	–	–

- Processes (Management of R&D (Research and Development) activities, Systematic learning and improvement, as well as Protection and assessment of results).

The Questionnaire used five options to evaluate the data collected. These options were designated as: Excellent (5 points), Integrated (4 points), Defined (3 points), Reactive (2 points) and Non-Existent (1 point). The maximum achievable value (number of researchers * number of questions * maximum option in questionnaire) was then subsequently calculated and compared with the actual results (Eq. (1)). The Maximum Value and the Achieved value are displayed in Table 5.

Table 5
Maximum and achieved values.

	Maximum	Achieved	Percentage (%)
Conditions	875	681	77.82
Resources	1250	886	70.88
Processes	875	611	69.82

$$\text{Achieved value} = \text{number of researchers} * \sum_{n=1}^{\text{number of questions}} (\text{options points} * \text{percentage results}) \quad (1)$$

On observing Fig. 3, one can see that the results for the Maximum values and those Achieved are very close. One can thus conclude that all the variables have been well worked on and developed at INESC TEC.

Based on the percentage values from Table 5, we can see that the Processes present lower values when compared to Culture and Resources. Yet, all of the three dimensions (Conditions, Processes and Resources) are close to the 75th percentile, which is a good indicator. However, this could be transformed into excellent if it is worked on through a continuous learning process. This logic leads one to require a greater understanding of what can be improved. To this end, one considered all the questions that obtained the lowest rating value for each dimension, and proceeded with the pertinent analysis.

For the first dimension (Conditions), and particularly when considering Strategy, namely question 7 related to the organization's innovation strategy (see Table 2), 8% of the respondents rated the existence of an action plan for medium and long term as excellent, 12% evaluated it as integrated, 72% as defined and 8% as reactive. These results seem to point out that the organization must improve its innovation strategy with a plan of action which includes quantitative purposes and targets in the medium and long-term. The examples of relevant practices for answering this question are the following: "RDI Policy" formulation, documentation and communication; strategic planning of the global activity of innovation, in particular the RDI projects portfolio; translating purposes into specific projects with the corresponding budget allocation; scheduling RDI projects and defining the chronological events (milestones) in order to obtain partial results; defining plans for the protection of results; establishing methodologies for affecting resources; and measuring the performance related to the plans, identifying errors and their causes, defining remedial measures and a possible review of the purposes.

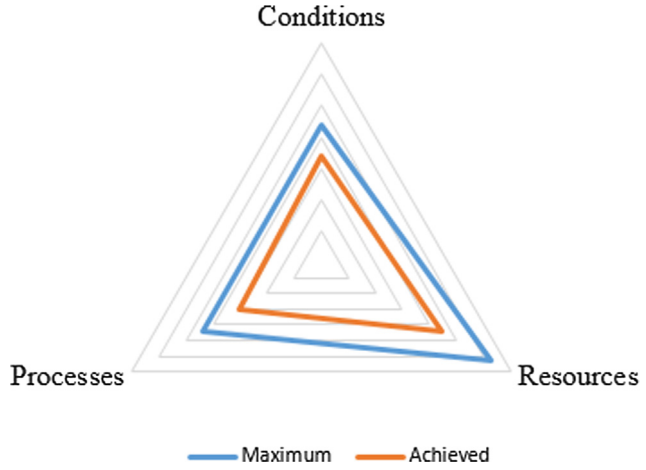

Fig. 3. Data analysis.

For the second dimension (Resources), questions 9, 16, and 17 (see Table 3) were rated as non-existent for 4% of the respondents. When this is the case, then the organisation drastically needs to improve in those categories or be made aware of this situation. In this dimension, the organisation must improve its training policy for staff in order to promote innovation. It should also provide adequate structures for knowledge management, as well as develop its information and communication systems to enable the innovation process. Examples of actions that are pertinent in a training policy guided towards innovation, are as follows: periodic assessment of the training needs according to the defined innovation purposes; follow-up and incentive for the continued development of the technological and professional competencies of the employees; supporting the participation of employees in scientific, technological and professional associations; specific training programmes in innovation management, development of new services and products in relevant behavioural areas which are appropriate to innovation (the capacity for initiative, leadership, team spirit, inter-departmental cooperation, and so on). Examples of the structures targeting the management of knowledge are as follows: organization of knowledge concerning "blocks" - groups of specialists who manage the maintenance and updating of specific knowledge; establishment of knowledge repositories that act as a "memory" of the organization; development of databases on "lessons learned"; use of tools for data mining; use of the intranet as a means of providing technical, economic and commercial information to employees; in the larger companies, databases of "who's who"; definition of mailing lists for each type of information; creation of physical and virtual meeting spaces, dialogue and sharing of knowledge and ideas like innovation points, innovation corners or innovation cafes; and the regular holding of seminars and sessions for divulging experiences and results. As concerning if the organization has information and communication systems enabling innovation, illustrative examples can be such as the implementation of Enterprise Resource Planning systems (ERP) and Customer Relations Management (CRM), Electronic Data Interchange (EDI), Radio-frequency identification (RFID), Intranets, or the increased worth of the tools presently available as the Internet or the Voice over Internet Protocol (VOIP).

Regarding the third dimension (Processes), question 21 (See Table 4) related to well-defined routines to build and define tasks for the project teams, 16% of the interviewees rated it as excellent, 64% rated it as integrated, 16% rated it as defined and 4% rated it as reactive. These results seem to point out that the organisation must improve and develop its systematic processes to enable inter-departmental cooperation. Well-defined routines for building and defining the tasks concerning the project teams is an issue that seeks to assess how the organization structures its project teams and establishes its purposes and mandate. This framework also examines the involvement of the top-management in the process and if the organization uses external partners as a way of introducing further capacities into the project teams, in a consistent manner. The following are some practices adopted by companies successful in innovation. One of the most common practices is the establishment of interdepartmental and cross-disciplinary teams. The appointment of a team leader tends to be made according to their specific, technical and behavioural competencies (capacity for leadership, experience in similar projects, ability to mobilize external resources) and their commitment to the project and not necessarily by criteria of seniority. In some companies, after basic criteria to be met are set, autonomy is given to the project team to self-organize. In other companies, there is a routine including a "passionate" person in the project team, but also a "non-believer", acting as challenger. In many cases, the team is

"open" to the outside world, namely customers, suppliers, and completers, integrating them in the project activities and benefiting from their specific know-how.

5. Conclusion and future work

The main results show that INESC TEC promotes innovation and assembles a wide range of conditions which encourage open innovation. The three dimensions are close to the 75th percentile, which is a good indicator.

The best dimension in INESC TEC is Conditions (77.82%), followed by Resources (70.88%). Processes appears at the bottom (69.82%). With a deeper analysis, it should be concluded that INESC TEC:

- must improve its innovation strategy as a plan of action, with quantitative purposes and targets in the medium and long-term;
- must improve its staff training policy to promote innovation; it should provide adequate structures for the management of knowledge and should also develop its information and communication systems to enable the innovation process;
- must improve and develop its systematic processes to foster inter-departmental cooperation.

This study highlighted the importance of contributing for the understanding and development of Research institutes, identifying the determinant characteristics of their innovative dynamic, such as adaptability, agility and ability to initiate change, through the main dimensions and pillars considered in the Innovation Scoring: (i) "Conditions", regarding the aspects that influence the attitudes and behaviour, through Culture (reflecting the adequacy of the company's values regarding innovation), and Strategy and Planning, (which seeks to assess how the characteristics of the organisation stimulate innovation); (ii) "Resources", that ensure innovation dynamics through Human Capital (assessing their involvement in innovation activities), Organisational Skills (relevant skills and capabilities for the team's innovative performance), External Relationships (mapping the main connections with other entities to enhance innovation) and Tools and Information Systems (assessing these as facilitators of innovation); and (iii) "Processes", as the basis for the generation of innovation performance, through RDI activities Management (including the importance given to Intellectual Property management), Management of Knowledge and Learnings (incorporation of obtained learnings) and RDI Projects Management (assessing processes for planning, organizing and monitoring RDI projects).

In this paper, the survey was conducted and directed at a limited number of researchers (25) from The Portuguese Institute for Systems and Computer Engineering, Technology, and Science (INESC TEC). The sample size is small and the people in INESC TEC have the similar background, which may not be a good representation of other industrial sectors. The survey considered only three of the four dimensions which is also a factor of restriction. For further work, five dimensions must be considered, namely: Conditions, Resources, Processes, Enhancers and Impacts. The survey might also represent a larger number of researchers, as well as senior executives in the organization. It would also be interesting to extend it to other research centers and universities, since they are key players in promoting open innovation in SME's (Small and Medium Scale Enterprises) and larger companies.

Conflict of interest

The authors declared that there is no conflict of interest.

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