Innovation Mechanisms based on Management of Business and Technology Knowledge Networks

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***Abstract*—In a changing and uncertain environment, innovation for technology companies represents a challenge associated with the resources needed to transform in-house and external knowledge into a valuable asset that can be incorporated into the company's value offer. The people in charge of these companies must be able to manage the necessary mechanisms to catalyse and incorporate best practices aimed at the end consumer. Through a qualitative study involving interviews with 7 technology companies, we looked at how the company manages its resources in the face of an uncertain environment. Our findings indicate that the mechanism is a direct relationship between entrepreneurial knowledge plus technology, which through the development of support networks eventually becomes innovation. This process influences the evolution of the technology company towards the development of sustainability.**

Keywords—Innovation, Technology, Knowledge, Networks, entrepreneurship, uncertain.

I. INTRODUCTION

The Covid-19 pandemic has put companies in different fields to the test, especially those developing innovation in the areas of health and disease prevention. Faced with an unexpected shock situation, the company is forced to find innovation mechanisms based on available business knowledge, in-house business skills and the management of available technology. These mechanisms make it possible to generate innovation using critical resources within the company and to incorporate new knowledge from external networks.

Technology companies are better able to cope with uncertainties and keep up with rapid market changes (Bolisani & Bratianu, 2017), being driven to navigate a dynamic knowledge-driven market. This is how knowledge-based innovation enables the creation of a sustainable basis for organisational competitiveness (Yu, Zhang, Lin, & Wu, 2017). This knowledge, however, is not always possible to generate through research and may be outside the boundaries of companies (Gaziulusoy, Boyle, & McDowall, 2013). Therefore, the configuration of networks that provide intangible assets is extremely important.

The literature on this topic argues that to increase their chances of success, firms should not rely solely on their own research and development of innovative goods and services (Hallstedt, Thompson, & Lindahl, 2013). To create advantages, they must draw on external sources of technology and innovation to support their management. However, in a scenario of shock and uncertainty caused by the environment, this process acquires a complexity that has not been explored in the literature. Therefore, our objective is to investigate knowledge-based innovation mechanisms and networks.

The integration of knowledge management into business processes aims not only to protect intangible assets, but also to develop and leverage internal and external assets, stimulating the creation of more competitive goods and services for customers (Ode & Ayavoo, 2020). Business processes are part of the elements that link the competencies of an organisation's members with customer demand and are therefore also instruments for the implementation and formalisation of knowledge management in the company (Seethamraju & Marjanovic, 2009). Therefore, as knowledge becomes an essential and strategic asset in the firm, organisational success increasingly depends on the firm's ability to produce, collect, store and disseminate knowledge.

Moreover, innovative capabilities generated by internal and external knowledge can play an essential role for organisational sustainability (Akram, Goraya, Malik, & Aljarallah, 2018). The development of new sustainable products and services adds complexity to the traditional process of new product development, but is equally a potential source of gains for the economy, society and individuals (Lopes, Scavarda, Hofmeister, Thomé, & Vaccaro, 2017).

II. METHODOLOGY

Through qualitative research we aim to answer the following questions What are the mechanisms by which managers transform internal and external knowledge into innovation? How does cooperation between stakeholders enable them to adopt changes in response to external shocks?

To answer these questions, we interviewed 7 firms that generated technological innovations in the context of the covid-19 pandemic to respond to the changing environment and cope with crises in various industries linked to health, surveillance and welfare. The sample was drawn from a pre-survey of 18 technology companies that have survived and innovated despite obstacles by leveraging knowledge and networks. From that sample we selected the representative cases given the objective of this research.

In the second stage, we met with the managers of the selected companies to investigate the characteristics of their initiatives. By means of an in-depth interview and the analysis of the cases through data coding, we identified the constructs that make up the innovation mechanisms through which knowledge management allows the incorporation of knowledge from support networks and also the management of the company's characteristics and available technology that are managed to serve as a catalyst for innovation in the absence of a planned R&D process.

TABLE I. CASES

Type	Innovation Cases		
	Innovation	***Technology***	***Knowledge***
Health	Proposes a solution that concerns a service for the transport of blood, blood components, organs, medicines, tampons and other medical products in order to prevent healthy people from going to hospital and exposing themselves to the risk of contagion.	Drones Robotic	Optimising the transport of critical inputs
Health	Open Innovation to deliver a low-cost ventilator made from car parts to the whole community	Artificial Respirator	Design Open Innovation
Localization/ Planification	City geo-referencing for a service that allows you to create surveys based on maps and 3D models and find out what the city's residents want to see.	Territorial planner GPS	Architect planner
Medical predictions	A set of tools to accelerate the development cycle of deep learning models with more transparency built on artificial intelligence.	Artificial Intelligence	Deep learning applications
Health	Mobile health information applications that enable organisations to help groups of people find health advice, signpost to local services, help people search for health information online, and help people find health information.	App/ Platform	Digital Health solutions
Tracking	Through a mobile data collection platform, it enables better information to help those in need. Organisations create mobile applications that improve the quality and efficiency of services in the most remote corners of the world.	Mobile platform	Collection Data
Software Support	Firm that provides a wide range, cost-effective, and full scale service to tailor-fit and empower businesses. Providing vision, strategy, and outstanding implementation in advanced software solutions.	Software engineering solutions	Team of expert programming engineers

[a.] Source: own elaboration with interview data.

III. FRAMEWORK

Knowledge

The competitive advantages of firms are increasingly derived from knowledge resources and their utilisation and development (Mahdi, Nassar and Almsafir, 2019). The knowledge-based view considers knowledge to be a firm's most strategic resource with the potential to generate sustained competitive advantage and superior business performance because it is socially complex and generally difficult to imitate (Cegarra-Navarro, Soto-Acosta, & Wensley, 2016). However, although knowledge is a key resource, without effective knowledge management systems firms cannot take full advantage of external knowledge, facilitating only incremental rather than radical innovation (Laursen & Salter, 2006).

In this sense, knowledge management seeks to optimise this resource, either from within the firm or from outside. The complementary nature of internal and external knowledge processes requires integrative knowledge management to successfully implement organisational innovation and thus generate innovation in technology-focused firms (Wu & Hu, 2018). The enterprise must also possess knowledge management capabilities to quickly assess and respond to competitors' actions. Knowledge management capabilities determine which knowledge is suitable for incorporation into the firms' knowledge base to achieve fit (Xie, Zou, & Qi, 2018). In

addition, strategic planning, implementation, and the updating and protection of strategic knowledge are necessary processes to achieve best practice adoption and improve business performance (Cabrilo, & Dahms, 2018).

Entrepreneurship

Entrepreneurship has attracted increasing interest because of its role in policy decisions that can foster economic and social development. Increased attention has also been paid to how entrepreneurs innovate and, consequently, contribute to increasing levels of international competitiveness (Ferreira, Fernandes and Ratten, 2017). This trend towards globalisation of organisations also implies strengthening relationships with related and supporting firms.

Motivation to innovate is an important issue for the development of demand-driven innovations, as innovative new products and services, and/or innovative production and distribution processes may be needed to solve societal problems (Santos, 2012). While innovation can be decisive for the achievement of sustainable outcomes, successful innovation is also expected to be decisive for the reinforcement of entrepreneurial characteristics, which arise due to self-satisfaction, self-esteem and recognition by others of one's own social responsibility and social accountability (Bacq and Alt, 2018).

Technology Management

Technology ventures are recognised as those that focus on how to foster opportunities through innovations in the use and availability of technology in business. These types of ventures can be diverse in nature, such as information enterprises, biotechnology, alternative energy and internet search sectors. In any case, it is noted that research in the area is concentrated in relation to firms rather than entrepreneurs and is defined as the development of new technologies by firms (Pathak, Xavier-Oliveira, & Laplume, 2016).

A business innovation of technological enterprises presents a structure that should be consumer-oriented and act in the direction of achieving the highest degree of satisfaction of the needs of the largest possible number of the target population (Branstad and Solem, 2020). On the other hand, the organisational effectiveness of the implementation of sources of funding for innovation and technology must be ensured in order to improve the competitiveness of the company (Drobyazko, Barwińska-Małajowicz, Ślusarczyk, Zavidna, & Danylovych-Kropyvnytska, 2019).

Innovation activity resources are a composition between technology and the opportunities they provide when applied in the production process and the implementation of innovative or other activities (Drobyazko, Hryhoruk, Pavlova, Volchanska, & Sergiychuk, 2019). These resources by their technological nature are not necessarily wholly owned by the firm, they may be part of a larger industrial network.

Technological innovation of firms has been strongly related to a firm's innovativeness and competitive advantage. This is because technology-based business opportunities are often more novel than others (Dorf & Byers, 2005) and this novelty implies that, on the one hand, a technology entrepreneur has a higher level of uncertainty than other types of firms (Venkataraman, 2004), but on the other hand presents options for rapid growth (Hindle & Yencken, 2004). Therefore, today's high-tech industries are characterised by a competitive environment and very short technological life cycles that require a support network.

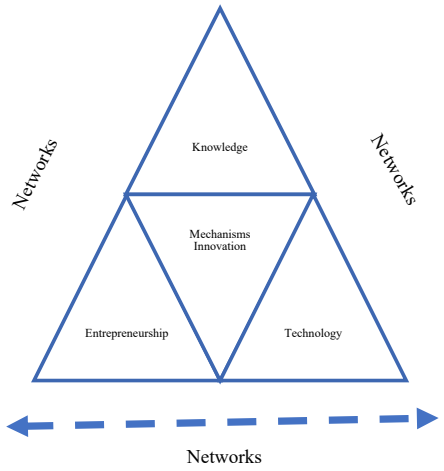

Fig. 1. Elements Model

TABLE II. MECHANISMS

Mechanisms Technology Innovation Cases		
Input	***Link***	***Output***
Biomedical knowledge of the founder	Government funding Partners in aerial transport using drones	Patented transport capsule
Knowledge of mechanical parts Knowledge of programming	Open Innovation Platform access "Bricolage"	Open-source mechanical ventilator plans
Knowledge of architecture Programming skills	Government support and funding	Geolocation and mapping based on population characteristics
Deep Learning Artificial Intelligence	Academic researchers Open Innovation	Predictive applications
Medical Experience Programming skills	Covid patients	Health Information Data Base
Expert programming engineers	Tracking of Covid-19 positive cases	Applications
Expert programming engineers	Customers with a need to digitise pandemic	Applications

Mechanisms Technology Innovation Cases		
Input	***Link***	***Output***
	management solutions	

[b.] Source: own elaboration with interview data.

IV. ANALISYS AND RESULTS

The results of the interviews with innovative technology companies make it possible to establish links between knowledge-innovation-technology as elements that make up the mechanisms of innovation in a scenario of crisis and uncertainty, taking advantage of and optimising the internal and external resources available. On the other hand, the characteristics of the institutional environment are also part of these mechanisms and their influence should make the difference between the success or failure of these initiatives (figure 1).

A mechanism is a set of parts or elements that, when fitted together and energised, perform a job or function. In this sense associated with innovation, the companies interviewed establish links with their networks to make the mechanisms of technological innovation work. In this sense, knowledge functions as the link that binds all the components together, while entrepreneurship and technology are the functional cogs that enable this mechanism to work.

The companies interviewed managed their networks to assess the best decisions for dealing with the pandemic. Particularly in health, the functioning of the innovation mechanism has been critical in responding quickly to changes in the environment and to people's demands. This last point is key, as solutions are not always received directly by the customer but are delivered as part of a larger value proposition associated with welfare and government policies along the same lines.

Entrepreneurship is also a key characteristic of companies that are able to capitalise on their knowledge networks for innovative development. The management capacity to capture and incorporate the best practices of the environment is one of the fundamental pieces of the mechanism and is associated with the knowledge that is created within the company. The technology companies interviewed have a high flexibility to adapt and this is part of a founder-driven organisational culture.

Technology is a valuable asset that is highly correlated with the ability to properly manage the development of innovation in this area. Innovation associated with technology can lead to the efficiency and competitiveness of the company's processes, so it is essential that knowledge in this area is shared and built collaboratively with all the actors involved. In the interviews it was very clear that the value offer that makes them unique does not depend only on a single technology but on a set of technologies and also on the technologies of the partners.

After a review of the data obtained, relevant information on the mechanisms by which entrepreneurial knowledge and experience are transformed into network-mediated innovation in technology companies was summarised. Table 1 summarises the main mechanisms used by the companies based on an input - Link - Output approach. For all participating companies, the pandemic situation was a trigger for new solutions or modifications to their business models. However, although they had been developing innovation processes, this was not enough to cope with the situation on their own. It was the influence of networks that determined the use of technology and creation of synergies to generate a useful outcome for the community.

Our main finding is that the business skills of the founders associated with both their technical knowledge and entrepreneurial skills were also instrumental in channelling the necessary resources to seize opportunities and deliver innovative solutions to the market. The speed of the entrepreneurial response facilitates the mobilisation of subsequent network support and resources to realise the innovation (see figure 2).

V. CONTRIBUTIONS

Our main contribution is based on relating the elements that enable the development of innovation as a rapid response to changes in the environment. This rapid response would not be possible without the networks that allow knowledge to be incorporated into the current value offer. In this sense, knowledge management of business skills and technology form a valuable capital that can be favourably managed to respond to a dynamic and constraining environment.

What all the companies in the study have in common is openness and support from external actors. In this case, all against a pandemic. Speed of response is therefore critical, and the company must be willing to increase its openness to mobilise knowledge (Chesbrough, 2020). Openness makes it possible to take advantage of the human capital available in the world as well as physical capital.

In this sense, we are faced with a type of open innovation that contemplates the conditions of the environment and allows us to advance in the definition of a mechanism based on conditions of uncertainty that can be applied to other types of environmental threats, as well as in the identification of the relevant actors in the process.

VI. IMPLICATIONS AND LIMITATIONS

The main implications for practice are the development of knowledge on how innovation is developed and managed in

the organisation in crisis situations by taking advantage of the resources available in the networked environment.

Increasing the level of external networks enhances innovation by broadening the knowledge base, which promotes the globalisation of organisations through the knowledge generated. Moreover, with the advancement of technologies, innovation networks have a completely different mode of operation and can involve different levels of stakeholders. In this respect, it is important to investigate the role of governmental entities as an active part of the network and also as part of the mechanism.

Finally, the main limitation is related to the number of cases. In this sense, this study is exploratory and will serve to establish guidelines for future research related to the innovation mechanisms of technology companies through their own and external knowledge in a changing environment.

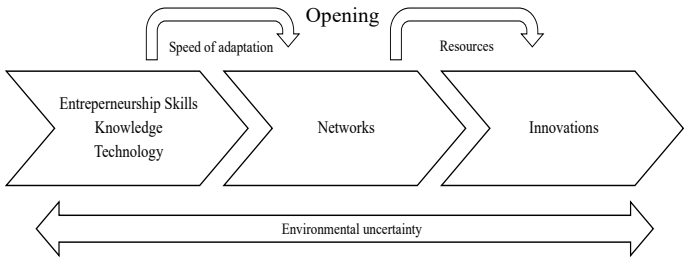

Fig. 2. Mechanisms Innovation

VII. Conclusion

Globalisation and the development of technology and know-how-based industries clearly represent the need to introduce and stimulate business innovation as an element of survival in an environment where competition is fierce, but collaboration is a factor of evolution.

Especially for companies in the field of health and support services, the introduction of innovation is one of the conditions for their effective functioning today and the possibility to access global markets. This is not only about technological or product innovations, which often cannot be realised due to lack of resources, but also about management, marketing and organisational innovations.

The collaborative mechanisms used by technology companies make it possible to establish a pool of resources available for innovation and the development and adaptation of companies. This is how a new condition of collaborative open innovation emerges in order to respond quickly to market requirements.

Therefore, both today and in the future, innovation mechanisms will have an important role to play in recovering from the social and the economic consequences of the coronavirus and in preparing a more sustainable and resilient environment.

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