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Research Article

Mapping the relationship between innovation, categories of knowledge and institutional context in an organisation

Cartografía de la relación entre innovación, categorías de conocimiento y contexto institucional en una organización

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Abstract: Organisations are social entities formed by individuals with knowledge in an institutional context. Innovation is a social and economic phenomenon (Schumpeter, 1935a) that positively impacts organisations and economic growth. This paper maps the relationship between innovation, categories of knowledge, and institutional context in an organisation. It reviews innovative organisations as opportunity takers in an institutional context and understands innovations as the output of a multidirectional process where articulated and unarticulated knowledge is exchanged by individuals in the organisation. Innovation becomes a decision-making (selection and variation) process based on an individual's knowledge. That process has velocity and direction due to its relationship with the institutional context and the categories of knowledge. The paper concludes by presenting a conceptual model to explain the relationship between the concepts studied. It integrates innovation theories, knowledge economy literature, and sociological perspectives.

Keywords: knowledge exchange; knowledge codification; innovation theory; innovation opportunities; institutional change; institutional context.

Resumen: Las organizaciones son entidades sociales formadas por individuos con conocimientos en un contexto institucional. La innovación es un fenómeno social y económico (Schumpeter, 1935a) que repercute positivamente en las organizaciones y el crecimiento económico. En este artículo se describe la relación entre innovación, categorías de conocimiento y contexto institucional en una organización. El artículo examina las organizaciones innovadoras como aprovechadoras de oportunidades en un contexto institucional y entiende las innovaciones como el resultado de un proceso multidireccional en el que los individuos de la organización intercambian conocimientos articulados y no articulados. La innovación se convierte en un proceso de toma de decisiones (selección y variación) basado en los conocimientos de un individuo. Ese proceso tiene velocidad y dirección debido a su relación con el contexto institucional y las categorías de conocimiento. El documento concluye presentando un modelo conceptual para explicar la relación entre los conceptos estudiados. En él se integran las teorías de la innovación, la literatura sobre la economía del conocimiento y las perspectivas sociológicas.

Palabras clave: intercambio de conocimiento; codificación del conocimiento; teoría de la innovación; oportunidades de innovación; cambio institucional; contexto institucional.

1. Introduction

Organisations produce goods or services to be exchanged in the market. Those products can or cannot be innovations. What differentiates the production of any good or service from innovation is the degree of novelty a good or service has. The Oslo Manual (OECD/Eurostat, 2018) explains that innovations can be classified according to their degree of novelty: New to the market or new to the organisation.

Innovation involves a set of activities, from the moment of ideation to the moment of market exchange. Nevertheless, such a process requires a relevant resource: the individual's knowledge. Then, innovation is considered a knowledge-based process, and like any process, it has an outcome: The innovation itself.

As a result, innovation has been studied as a process by Kanter (1984), Van de Ven (1986), Van de Ven and Polley (1992), Adner (2006), Birkinshaw et al. (2008); as an outcome by Barnett (1953), Levitt (1960), Becker and Whistler (1967), Utterback (1971), Jaffe et al. (1993), Davenport (1994), and as a knowledge-based process by Schumpeter (1935a), Myers and Marquis (1969), Dosi (1988), West and Farr (1990), Greve and Taylor (2000), Gupta et al. (2007), Tidd and Bessant (2005) (this last group was cited by Quintane et al., 2011).

There are two literature approaches to knowledge. The first one tries to understand where knowledge resides, and authors such as Collins (1993) and Blackler (1995) have categorised knowledge according to it. Consequently, they talk about embrained, embodied, encultured, embedded, and encoded knowledge.

The second approach studies knowledge from its nature perspective; it distinguishes articulated knowledge from unarticulated and unarticulable knowledge. Some authors that have studied knowledge from this perspective are Polanyi (1967), Nelson and Winter (1982), Nonaka and Takeuchi (1995), Cowan, David and Foray (2000), Steinmueller and Cohendet (2000), and Lundvall and Lorenz (2002). Polanyi (1967) was the first to state that people know more than what they can communicate and established the importance of tacit knowledge.

In the production process of innovation, there is uncertainty, so it must be managed (Tidd and Bessant, 2009; Simao, Carvalho and Madeira, 2021). Organisations manage uncertainty by establishing rules and agreements between individuals and other organisations. Sometimes, those rules emerge spontaneously in a particular context; therefore, another concept related to innovation emerges: Institutions (North, 1990).

According to North (1990), Knight (1921) and Coase (1937) began to redirect the attention of economists to the organisation. Knight focused on the uncertainty analysis and Coase on the concept of transaction costs, which gave sense to the organisation's existence.

The study of organisations and the production of innovation is a matter that has worried scholars since a long time ago. Different theoretical thoughts have been exposed to understand the social phenomenon of innovation. Previous research shows the relevance of knowledge sharing for the development of innovative behaviour (Soares, Mosquera & Cid, 2021).

Neoclassical thought presents individuals and organisations as having perfect information, rationality, and competence. They use mathematical and statistical models to understand reality. Knowledge was first considered as an exogenous variable, but later it became an endogenous variable in the models of economic growth.

The second stream of thought comes from the Austrians, based on methodological individualism. In consequence, they developed the free-market theories. They established that the best way of using knowledge, initially dispersed among all the people, is at least one of the main problems of economic policy.

Another stream of thought that has studied innovation is the evolutionary one. It preaches that economic processes evolve and that economic behaviour is determined by both individuals and society as a whole. They affirm that there is a commercially organised state where private

property, division of labour and free competition prevail. Here, innovation is defined as a social and economic phenomenon.

Finally, institutionalism criticises the rational and static vision of neoclassical models. It emphasises the importance of analysing institutions (formal and informal) from a historical perspective and organisational dynamics. It focuses on understanding the evolutionary process and the rules that shape human interaction to understand economic growth and change.

The findings on the relationship between innovation, institutions and categories of knowledge will be developed in the following sections. First, it will be explained how organisations are described as opportunity takers in an institutional context. Then, the relationship between innovation and knowledge will be described.

2. The innovative organisation: Opportunity taker in an institutional context

The innovative organisation is a concept used by Drucker (1969) to describe those organisations that are opportunity takers in a discontinuous context. North (1990) used opportunity takers to refer to how organisations achieve their goals in an institutional context. What they mean is that organisations develop their economic activities in a particular context that changes through history. That particular context has rules that are considered incentives to facilitate (or sometimes not) different interactions.

When rules change, organisations have different decisions to make. One of them is to see an opportunity and take it. Another decision could be to disappear. An innovative organisation sees the opportunity and takes it.

Opportunities can come from a change in the rules of market exchange, changes in the rules that a new technology imposes, or changes in another kind of rule. North (1990) points out that institutions are those rules, and organisations are the players. "Organisations (and their entrepreneurs) engage in purposive activity and in that role are the agents[1] of, and shape the direction of, institutional change" (North, 1990). Hodgson (2006) clarifies that some people have interpreted North as saying that organisations are not institutions, but North has not written this. He is not interested in the social rules internal to organisations because he wants to treat them as united players and focus on the national or other higher levels.

The study of institutions in economics has already spanned more than one hundred years (Chavance, 2018). One of the first authors who brought the institutional analysis to economics was Schmoller (1900). He defined institutions as a set of habits and rules (custom, moral, law) with one objective: to form a system. He differentiated "organs" from institutions: marriage is the institution, but family is the "organ". He also focused on the analysis of the State. Veblen (1904) defined institutions as habits of common thought and actions. He implicitly considered that organisations are institutions. He focused on institutions such as property, business enterprise and the leisure class. Commons (1934) described institutions as collective actions that control individual action. According to him, organisations are institutions, and the ones he observed were the Common Law and the monetary system.

Until the 1930s, institutionalists had influence, but after the 1940s, their thought was relegated due to the rise of the neoclassical school, which considers institutions as external factors in economic analysis. It was not until the 1980s and more strongly in the 1990s that institutions returned to the centre of discussion in the different schools of economic thought (Chavance, 2018).

Williamson (1985) defined institutions and organisations as transaction forms of governance, and the institutions he analysed were hierarchies and markets. North (1981, 1990) analysed the

[1] Agent is a person or thing that takes an active role or produces a specified effect. In economics, an agent is an actor (more specifically, a decision-maker) in a model of some aspect of the economy. In social science, agency is defined as the capacity of individuals to act independently and to make their own free choices. In contrast, structure are those factors of influence (such as social class, religion, gender, ethnicity, ability, customs, etc.) that determine or limit agents and their decisions. The influences from structure and agency are debated—it is unclear to what extent a person's actions are constrained by social systems. (Barker, 2005).

role of institutions (or the game's rules) in historical and structural change. He focused on the analysis of formal and informal institutions concerning market and property. Hodgson (2006) said that institutions are systems of social rules embedded in structures and interactions. According to him, organisations are institutions that establish internal rules to execute their purpose, but he also recognises external rules. One of the institutions he has studied is the language.

Nelson and Winter (1974, 1977, 1982) overlooked a lack of integration between aggregate analysis and organisational studies. They took the Schumpeter's vision of capitalism as a base to propose an Evolutionary Theory of Economic Change as an engine of progressive or evolutionary change (Nelson & Winter, 1982).

Individuals in an organisation (managers, employees, suppliers, stakeholders, and others.) have the skills to produce goods and services and make decisions. A skill is the capability of achieving objectives given the context in which an organisation acts. Skills are to individuals what routines are to organisations, and routines are the institutionalised capabilities of an organisation (Nelson & Winter, 1982). Therefore, each organisation has its own capabilities to innovate. According to Polanyi (1967), the knowledge that underlies a skilful performance is considerably tacit.

The kinds of knowledge, skills and learning that members of an organisation acquire will reflect the payoff of institutional constraints: "organisations will also encourage the society to invest in the kinds of skills and knowledge that indirectly contribute to their profitability. Such investment will shape the long-run growth of skills and knowledge, which are underlying determinants of economic growth" (North, 1990).

3. Knowledge and its relationship with innovation process

Innovation is a social and economic phenomenon (Schumpeter, 1935a) that positively impacts organisations and economic growth. Schumpeter (1935a) exposed that development is a spontaneous and discontinuous change that alters and displaces the equilibrium state, while innovation is a phenomenon that produces development and is a historic and irreversible change in doing things (Schumpeter, 1935b). Moreover, according to Schumpeter (1935a), this change appears in the industrial and commercial spheres, and it carries out new combinations of productive means: "The introduction of a new good, a new production method, a new market, the conquest of a new source of supply of raw materials or half-manufactured goods and the carrying out of the new organisation of any industry" (Schumpeter, 1935a). Therefore, Schumpeter (1939a) defines innovation as the setting up of a new production function.

Knowledge production and diffusion are processes that were into Schumpeter's thinking, as does the impact of those processes on economic growth and organisations. "However, Schumpeterian thinking was novel in emphasising the destruction and disorder that entrepreneurs caused by their innovation. That is one of the main features of the knowledge-based economy" (Foray, 2004).

Smith (1776), in The Wealth of Nations, starts talking about the division of labour; he recognised that the worker's knowledge and specialisation increased productivity. Hayek (1945) exposes his idea of the division of knowledge instead and says that the economic problem of society is a problem of the utilisation of knowledge.

Marx (1887), in The Capital, explains how the capitalist system is an evolutionary, dynamic, transitory mode of production. He examines technological changes and points out how a new machine performs the work of ten days in one day; thus, he analyses how innovation and knowledge impact the productive system, although he was not explicit on that.

Nelson (2005) states that the idea that technical advance often results from prior investment in Research and Development (R&D) is not new. Also, the idea that education is reflected on human capital was considered long before it was incorporated in formal models. Solow (1957) introduces the rate of technical progress in the analysis of economic growth, but still, he takes it

as an exogenous variable. He explains that technical change is any shift: slowdowns, speedups, improvements in the education of the labour force, and all kinds of things may appear as "technical change", but what causes technology to change over time is not described in his model.

Machlup (1962) says that it is relevant to talk about an exogenous or endogenous variable, determined by the system of functions. He considers that knowledge must be analysed as an endogenous variable. His main contribution is on the understanding that there is "production and distribution," "acquisition and transmission," "creation and communication" of knowledge. In his analysis of production and distribution of knowledge, he highlights that innovation is different from an invention. He refers to Schumpeter, saying that innovation is not the work of a scientist or engineer, but rather the decision of an entrepreneur risking investment funds on a new venture; thus it is not invention, although it may use an invention.

Arrow's (1962) proposes an endogenous theory of economic growth where the changes in knowledge underlie intertemporal and international shifts in production functions. This author affirms that knowledge has to be acquired, and the acquisition of knowledge is usually termed " learning," which is the product of experience. Therefore, he uses cumulative gross investment (cumulative production of capital goods) in his model as an index of experience.

What is visible is that during the first half of the XX century, there was an increasing interest in economics in analysing the role of knowledge in economic activities. Later, the focus was on the analysis of the process of the generation of knowledge and its role in improving economic competitiveness and societal development (Aparicio, Iturralde & Rodríguez, 2021)

Philosophers studied knowledge and developed the epistemology or theory of knowledge. Other disciplines analysed different problems of knowledge. However, economics increases interest when knowledge becomes an economic activity and an endogenous variable that impacts economic growth and innovation.

In the literature, there is an aggregate analysis, which means an analysis from a macro-level, but the data was taken from organisations. It was considered that individuals with knowledge integrated those organisations. Knowledge was used to produce goods and services to make decisions. At that time, the interest of economists was more visible in variables at a level of aggregation instead of that of individual organisations, often macroeconomic variables, and even "microeconomics", which were about industry-level rather than organisational level variables (Nelson, 2005).

4. Categories of knowledge and its role in the innovation process

According Polanyi (1967), who was the first to affirm that we know more than we can communicate, established the importance of tacit knowledge. It is based on education, ideals, values and feelings. Tacit knowledge is always subjective and intuition-based, deeply embedded in the experience of a human (Lesjak & Natek, 2021).

Cowan et al. (2000) present a knowledge topography where they divide knowledge into three categories: articulated knowledge, unarticulated knowledge and unarticulable Knowledge. However, they left out the third one[2], focusing their analysis on the articulated and unarticulated knowledge. Lundvall and Lorenz (2002) critically assess Cowan's et al. (2000) paper. They argue that the dichotomy between codifiable (articulated) and non-codifiable (unarticulated) knowledge can be problematic. It is impossible to transform knowledge into a codified form without losing its original characteristics because they cannot be included in the codebook.

On the one hand, there is articulated knowledge, which is articulable and codified; thus, it implies the existence of a codebook[3], which means the development of a codebook building process. This process goes from *a priori* knowledge identification to the standardisation of new

[2] Unarticulable means that it is not possible to be codified or articulated, so, there is no interest of the authors in these kind of knowledge.

[3] A codebook is defined as a kind of dictionary that is used by the agents to understand written documents, but also written documents are a codebook (Cowan, David and Foray, 2000).

models, languages, rules and vocabulary around that knowledge. In summary, there is a collective action to build new standards and finally codify that knowledge. Codification is made with the purpose of exchanging knowledge (Steinmueller & Cohendet, 2000)

On the other hand, unarticulated knowledge, or the one that has not been codified or articulated, is divided by Cowan et al. (2000) into two subcategories. In the first one, the existence of a codebook can be recognised, but it has been absolutely internalised, so it is called the displaced codebook. The second one is where there is no codebook.

When there is no codebook, Cowan et al. (2000) show two subcategories that refer to the existence of agreements or disagreements. When there are agreements, they talk about collective memory; but when there are disagreements, they refer to a procedural or not procedural authority.

This analysis is important because Cowan et al. (2000) controvert the simple distinction between codified and tacit knowledge. They also get deep into different hues that tacit knowledge can have. These authors affirm that identifying, for example, the zone where knowledge is codified, but the codebook has been displaced is a very important result of their model. If knowledge is highly codified and the codebook is displaced, a new need for knowledge transactions can be fulfilled at a lower cost, while when there is no codebook at all, there is a cost of producing a codebook, it means to develop languages and models (Cowan et al., 2000). According to Cowan et al. (2000), these results would re-examine many empirical studies. It is concluded that tacit knowledge is the key in many activities. The difference between what the author calls "true tacitness"[4] and highly codified knowledge must be observed.

North (1990) establishes the importance of institutions for analysing economic growth and innovation. He explains that it impacts the generation of new knowledge in organisations. Cowan et al. (2000) explain that there are different categories of knowledge and that unarticulated knowledge is of particular interest. They controvert those who consider all unarticulated knowledge as tacit when he establishes the displaced codebook.

Both authors refer to how knowledge drives changes in their context, and at the same time, context drives changes in knowledge. Both refer to transaction costs, in this case, knowledge costs, and how those costs affect the decision of codifying and diffusing knowledge (North, 1990; Cowan, David & Foray, 2000).

North (1990) states that organisations should invest in tacit knowledge[5]. However, according to Cowan et al. (2000), it is necessary to understand what types or categories of knowledge exist to make a more efficient investment and develop their model from a single to a transactional point of view.

Codification of knowledge has been intensely discussed over the last 20 years. There are two visions about codification and its relation to innovation. In the first one, codification can limit innovation. In the second one, codification facilitates knowledge exchange and new ideas from the cumulative knowledge in an organisation. Annex 1 shows the evolution between 2000 and 2020, discussing the nature of knowledge and how the categories of knowledge affect the innovation process.

[4] By "true tacitness" the authors want to question the real tacitness of a knowledge that is not really tacit and instead has been highly codified and internalised.

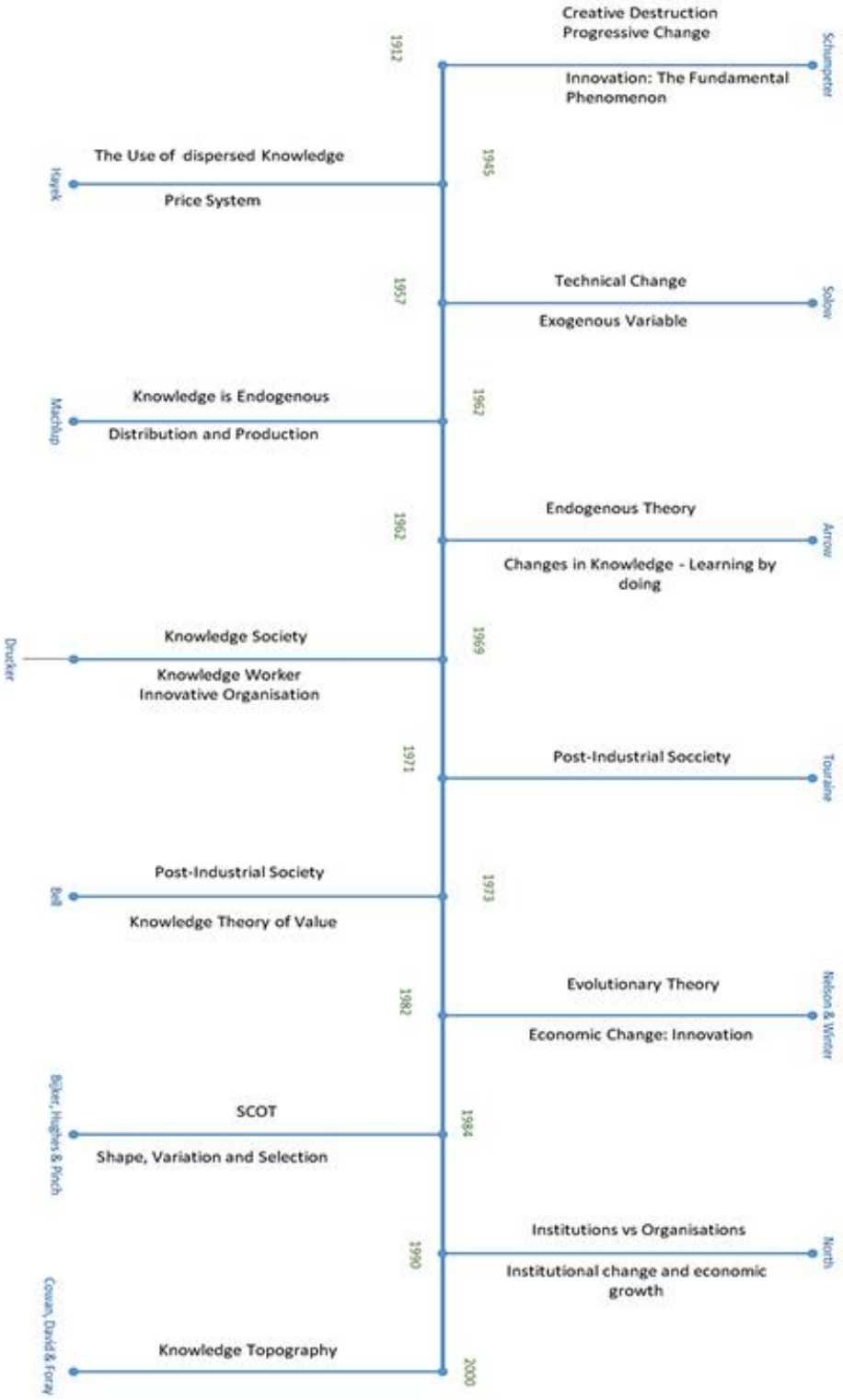
[5]Nonaka & Takeuchi (1995) present a model currently followed of how is the conversion between explicit and tacit knowledge. From that model different strategies have been developed on how to invest in such a relationship. They present four ways of conversion from explicit to tacit (internalisation), from tacit to explicit (externalization), from tacit to tacit (socialisation) and from explicit to explicit (combination).

5. Discussion

After doing this exercise of reading and looking for how the theory connects the concepts of innovation, categories of knowledge and institutions, there was a reflection time to organise the ideas and build a map to see how the theory was evolving through the years (Figure 1). Some reflection thoughts that emerged are:

- Society produces goods and services and uses some resources to produce them (Smith, 1776; Marx, 1887).
- Innovation is a process of change: A change in the production function (Schumpeter, 1935a).
- The change is given by the combination that each organisation has of the resources in the production function (Nelson & Winter, 1982).
- One important factor in the production function is knowledge (Solow, 1957; Drucker, 1969).
- Knowledge is taken as an endogenous variable when analysing economic growth (Arrow, 1962; Machlup, 1962).
- Knowledge is dispersed in society: there is nobody who knows everything (Hayek, 1945).
- There are different types of knowledge and different categorisations (Polanyi, 1967; Cowan, David & Foray, 2000).
- Institutions are those rules that society defines to carry out an objective. To have a business, individuals build organisations and follow some rules given in their particular context (North, 1990).
- There is variation and selection in an innovation process (Pinch & Bijker, 1984).
- A particular context defines knowledge, rules, and selection (Hayek, 1945; North, 1981; Schumpeter, 1935b).
- Society has overcome structural changes that made economic activities evolve from manual to mechanics to knowledge-based ones (Bell, 1973).
- Technology is an institution. Technology rules the way society produces and consumes (Pinch & Bijker, 1984).

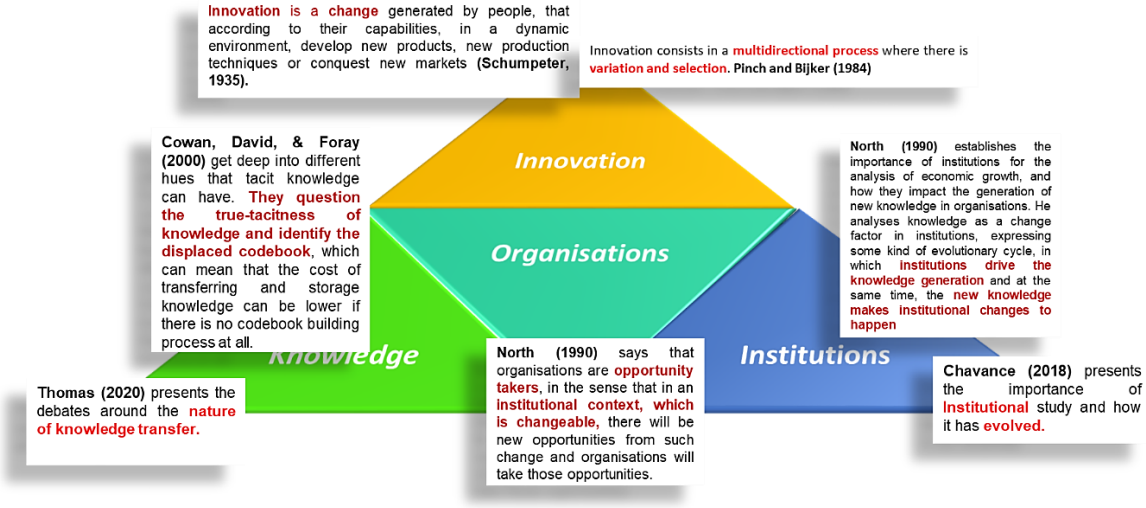
Figure 1. Mapping the relationship between innovation, categories of knowledge and institutional context.



Source: Author's elaboration.

After having mapped the theoretical contributions of seminal authors, the next step was to identify which of those thoughts explain in a better way the relationship between innovation, categories of knowledge and institutional context. Figure 2, shows the theoretical approaches that can explain this relationship. Organisations become the central entity to be studied to understand that relation.

Figure 2. Theoretical Framework.

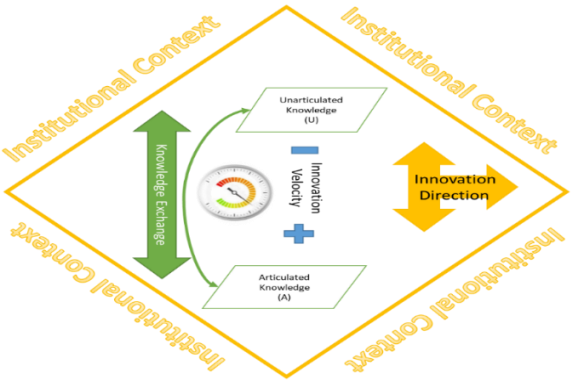


Source: Author's elaboration.

The references selected in Figure 2 is the result of an extensive analysis of the concept of innovation. In this paper, the researchers understand that innovation is a process, but it is a process in which individuals with knowledge intervene. It is understood that knowledge can be articulated or unarticulated. The articulation or codification of knowledge is a process of social building, and innovation is a process that occurs in organisations and that they develop in a social context in which there are particular rules of the game, institutions. Finally, innovation is multidirectional, which means that there are multiple options and opportunities, and because of that, there is selection and variation.

The integrated perspective of the concepts shown in Figure 4, has driven the researchers to propose a conceptual approach about the relationship between innovation, categories of knowledge and institutional context in an organisation (Figure 3).

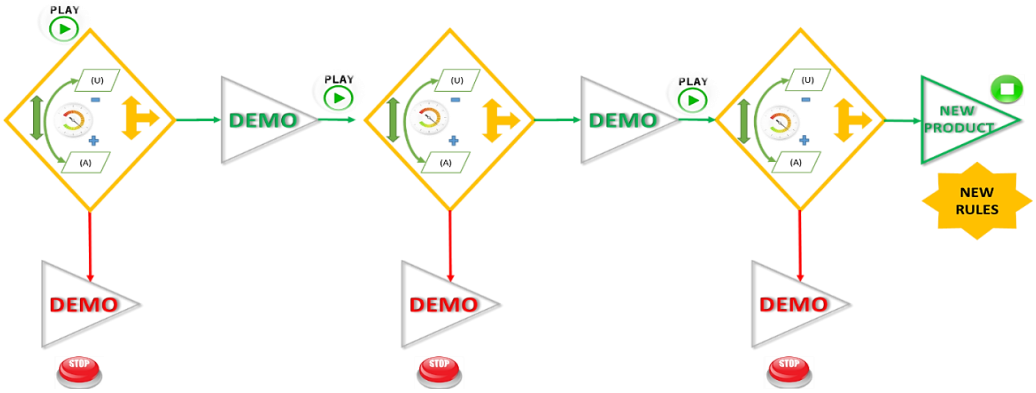
Figure 3. Conceptual approach about the relationship between innovation, categories of knowledge and institutional context in an organisation.



Source: Author's elaboration.

Figure 4 models the way in which different categories of knowledge are exchanged in a particular context. This conceptual model tries to explain the relationship between innovation, categories of knowledge and institutional context. It is necessary to change the production function to innovate, which means to change the combination of resources used to produce. One of them is knowledge, as it changes when it is exchanged, and this transaction is given in two general categories: unarticulated and articulated knowledge.

Figure 4. The relationship between innovation, categories of knowledge and institutional context.



Source: Author's elaboration.

The innovation process happens in an institutional context. It means that organisations, the players, are involved in a set of institutions or rules that can be established in different fields. Institutions give direction to the innovation process because those rules can affect selection and variation to develop a new product, as it becomes a matter of decisions. And knowledge gives velocity to the innovation process; it is supposed that articulated knowledge gives more velocity to the innovation process in the sense that it is easier to exchange it. Here it is important to refer to Cowan, David and Foray (2000) when they propose the existence of the displaced codebook.

Figure 4 represents how each moment in the innovation process becomes a decision. There is a process of selection where the exchange of knowledge and the institutions involved produce a variation (Demo) of the product. The final decision is made to obtain innovation, a new product in the market.

6. Conclusions and future research

After Innovation is a powerful and robust concept with its roots in different areas of study such as economics and sociology. Sometimes the word innovation is overused, and the problem is not to understand its meaning but how innovation can impact organisations of all kinds. Innovation is a new product: it seems simple; however, what does it mean to produce something new? That is the question that emerges after reading the authors mentioned in this review.

The production of something new strongly impacts daily life. It gives employment to those who start producing it and changes the lives of those who start consuming it. Moreover, going back to the creation process, it changes the minds of those who create because they use knowledge before, during and after the creation process.

The purpose of this article was to map the relationship between innovation concepts, knowledge categories and the institutional context in an organization. In this sense, a judicious review of literature related to these concepts was carried out and an attempt was made to find the connection between them.

In the first part, the relationship between innovation and the institutional context was presented. An innovative organization is defined as one that observes opportunities in a changing institutional context and seizes those opportunities to take advantage of them. An institutional context defines the rules of the game in a particular context and it is knowing how to play those rules and/or break them, and taking advantage of it that leads to innovation.

It could be thought that knowledge and its relationship with the innovation process is an obvious relationship, you need knowledge to innovate. But it was not too obvious, it is necessary to understand what categories of knowledge exist and how they are related to innovation. According to the literature, the categories of articulated and unarticulated knowledge were identified, and they give velocity to the innovation process in the sense that it lets the knowledge be transferred or not.

The map showed in Figure 1, presents the evolution in the understanding of the innovation process and its relevance in the economic growth studies. At the same time, it shows how the concepts of institutions and knowledge have evolved and be integrated to the innovation analysis.

There is no integrated view that makes explicit the relationship between innovation, knowledge categories and institutional context. All these reflections are dispersed in many different papers and books. Knowledge categories have been eclipsed by a dominant and simple distinction. When looking for those who cite Cowan, David and Foray (2000), they rarely appear because of their knowledge topography. The institutional analysis goes over formal restrictions such as property rights. Therefore, future research can be directed to understand the relationship of formal and informal institutions and different categories of knowledge in an innovation process over different economic activities.

Appendix

Appendix 1. Articles about knowledge codification and innovation (2000 – 2020).

Author	Methodology	Purpose	Contribution
(Jenkins, 2000)	A case study in Formula One racing	It studies how innovation and imitation are facilitated by the process of knowledge codification in engineering areas.	Codification facilitates innovation and imitation. Conceptual knowledge is more widely available and understood by other engineers, whereas more practical knowledge tends to be more idiosyncratic, informal and uncodified.
(Foray, 2001)	Case Study of the primary education sector	It tries to understand how the creation and circulation of knowledge work in the education sector and how they affect the process of knowledge advances.	The low level of codification hampers access to and expansion of professional knowledge.
(Grimaldi & Torrisi, 2001)	Case Study of five Italian software firms	The paper tries to understand the incentives to codification.	Some firms tend to perceive the codification of knowledge of its senior experts with international quality standards (e.g. ISO 9001) as a source of organisational rigidity that can hamper innovation.
(Lissoni, 2001)	Case study on Brescia mechanical firms	It makes a review of the concepts of "tacitness" and "codification" and the concept of "localised knowledge spillovers".	Knowledge circulates within a few smaller "epistemic communities"; it does not flow freely in cluster boundaries.
(Roberts, 2001)	Conceptual Paper	The paper makes a review of the nature of knowledge and analyses the drivers to codify, including technological and economic factors.	Tacit knowledge is underestimated when running a codification process that brings important consequences for knowledge creation and innovation
(Lundh-Snis, 2001)	Case Study of manufacturing firms from Sweeden and Denmark	The paper tries to understand the role of knowledge codification and classification in organisational learning and innovation.	The analysis demonstrated the strength of knowledge exploration situated in a social context of shared practice as a means of providing ICTs that codify knowledge.

Author	Methodology	Purpose	Contribution
(Balconi, 2002)	Case studies of three firms are presented regarding the steel, semiconductor and mechanical sectors	This paper studies the increment in the codification of technological knowledge in the last twenty years due to low-cost electronic automation and measurement instruments.	Tacit knowledge has become complementary to a codified knowledge base and concerns problem-solving heuristics, interpretation of data, etc.
(Nightingale, 2003)	Conceptual paper	The paper analyses the tense relationship between knowledge theories.	Criticise the binary distinction between tacit and codified knowledge and argues that there is confusion when some theories propose that information technologies allow the codification of tacit knowledge.
(Cowan, Jonard & Özman, 2004)	Simulation Study	The measure of innovative potential considering the extent to which knowledge and available technological opportunities can be codified.	Long – run knowledge growth is increased in spatial clustering of industries where there is a high tacit knowledge rate.
(Brusoni, Marsili & Salter, 2005)	Multiple regression analyses. It used the Netherlands Community Innovation Survey (II) and covers over 2001 firms in 11 manufacture industries.	It studies the debate about the role of knowledge codification in innovation behaviour.	Firms with absorptive capacity and high technology sectors have a major use of codified knowledge.
(Hildreth & Kimble, 2005)	Conceptual Book	It presents how Communities of Practice strenghten the innovation process through the knowledge networks.	Communities of Practice (CoP) are social networks based on organisational learning that enhance organisational effectiveness.
(García-Muiña, Pelechano-Barahona & Navas-López, 2009)	Exploratory factor analysis in a sample of Spanish firms from the biotechnology sector	It analyses how knowledge codification influences technological innovation.	On the one hand, knowledge codification helps to develop incremental innovations and, on the other, firms must incorporate systems of legal protection into their codification practices if they want to keep their innovations exclusive.
(Vaccaro, Veloso & Brusoni, 2009)	Multicase comparative approach in the automotive sector.	This paper analyses the organisational creation process in new product development projects were virtual teams are involved.	Virtual technologies support the creation and transfer of new knowledge – both explicit and tacit.
(Li *et al*., 2010)	Multiple regression analyses. A sample of 607 Chinese manufacturing firms	It evaluates the assumption that organisational controls restrict innovation flexibility or enhance innovation by focusing the efforts of R&D professionals.	The analysis demonstrated that a social context of shared practice is a means of knowledge codification through ICTs.
(Kianto, 2011)	Multiple regression analyses. A sample of 1,001 employees in 54 SME	Analyses the influence of knowledge management on continuous innovation.	The results demonstrate that the following processes boost continuous Innovation: Knowledge assets, strategic management of knowledge, knowledge codification, knowledge sharing and knowledge acquisition.
(Bettiol, Di Maria & Grandinetti, 2012)	Case Study. Two knowledge-intensive business services (KIBS) are localised in Bangalore (India) and Treviso (Italy).	Analyses the relationship between creativity and standardisation in the innovation service process.	KIBS can use a knowledge management strategy to balance creative outputs with standardisation
(Costa & Monteiro, 2014)	Systematic literature review.	It studies the knowledge process and its relation with absorptive capacity and innovation.	Knowledge creation, acquisition, sharing, codification and exploitation are the most popular topics in the knowledge processes-innovation relationship.

Author	Methodology	Purpose	Contribution
(Gonzalez-Cristiano, 2016)	Case Study of freelancers in the field of cultural and creative industries (CCIs).	This article has the objective to observe knowledge conversion in development processes.	Freelancers use a general knowledge transfer process with the aim to understand and codify the client's knowledge. The process steps are creating an abstract concept, relating stories, keywords identification and concepts drawing, which is used as the raw material for the final design.
(Kabir, 2016)	Conceptual paper.	It aims to understand knowledge management at the ideation stage in the innovation process	The authors identified two sets of strategies related to knowledge and innovation: codification and personalisation and exploration and exploitation. At the ideation level, the firm decides what combination of strategies will best suit its innovation goals
(Lee *et al.*, 2016)	Multiple regression analysis. 55 firms located in the United States (US) and the United Kingdom (UK), including computer, electronics, software, instruments, and chemical industries.	The paper seeks to understand the importance of the new product development process of inter-temporal integration	Organisational practices designed to transfer tacit knowledge enable a firm to effectively utilise codified knowledge to enhance product development cycle-time performance.
(Xie *et al.*, 2016)	Case Study of Vanke, leading Chinese property developer.	It explores how standardisation (i.e., when a firm pursues standards to further innovation) involves different search processes for knowledge and innovation outcomes.	Knowledge complexity and codification can be combined to produce four types of the search process: active, integrative, decentralised and passive, which in turn result in four types of innovation outcomes: modular, radical, incremental and architectural.
(Serhan & Kabèche, 2017)	Case study applying the activity system model on the French multinational food Groupe (Danone).	This paper studies the outcomes related to learning and innovation that result from the implementation of knowledge codification strategies	This study opens the debates of ISO 9001 implementation with the lens of the "practice-as-strategy" approach based on the social theory and the evolution of codified routines. The process of implementing standard principles appears to be more like the management of contradictions and paradoxes to go beyond what the codified tools can offer to a system seeking creativity and innovation.
(Choudhury & Kim, 2019)	Multiple regression analyses.	To study the recombination process of traditional knowledge of migrants in U.S.	A major supply of first-generation ethnic migrant inventors increases the rate of codification of herbal knowledge at U.S. Skilled ethnic migrants bring to their employer's unique knowledge from the cultural context of their host country
(Thomas, 2020)	Conceptual paper.	It presents a literature review about the nature of knowledge transfer and tries to identify the debates around that concept.	The authors proposed a model that examines knowledge transfer from a broader perspective, thus encompassing various theoretical perspectives.

Source: Author's elaboration from Scopus 2020.

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