

Analyzing the Relationship between Digital Tools Use and Open Innovation Approach in Algerian companies

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Received:23/09/2021

Accepted :21/01/2022

Published :31/01/2022

Abstract:

This paper examines the role of digital technologies in the open innovation approach in Algeria's manufacturing industry. The purpose is to analyze the part of digital tools in improving innovation capabilities and open innovation through a survey of 68 Algerian manufacturing companies. In addition, digital tools that support the open innovation approach are empirically identified. The study results show that digital tools can facilitate innovation activities, focusing on their use as a response strategy to the needs of companies, improving their innovation process, and ensuring sustainability. In addition, a higher degree of knowledge sharing with external partners favors the innovation orientation of the Algerian manufacturing companies. The results also indicate that some digital tools will support and enable open innovation.

Key words: Digital tools, open innovation, innovation activities, R&D, Algerian manufacturing companies

Jel Codes Classification : O30,O32, O33, L60.

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تحليل العلاقة بين استخدام الأدوات الرقمية ونهج الابتكار المفتوح في المؤسسات الجزائرية

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تاريخ النشر: 2022/01/31

تاريخ القبول: 2022/01/21

تاريخ الإرسال: 2021/09/23

ملخص:

المهدف من هذه الدراسة هو تحليل دور استخدام التقنيات الرقمية في تعزيز نهج الابتكار المفتوح بواسطة دراسة ميدانية على عينة مكونة من 68 مؤسسة صناعية في الجزائر، بالإضافة إلى تحديد التقنيات التي تدعم هذا النهج. تظهر نتائج الدراسة أن الأدوات الرقمية يمكن أن تسهل أنشطة الابتكار، مع التركيز على استخدامها كإستراتيجية استجابة لاحتياجات الشركات، وتحسين عملية الابتكار، وضمان الاستدامة. كما ان مشاركة المعرفة مع شركاء خارجيين يدعم التوجه الابتكاري لمؤسسات التصنيع الجزائرية. تشير النتائج أيضًا إلى أن بعض الأدوات الرقمية ستدعم الابتكار المفتوح.

الكلمات المفاتيح: الأدوات الرقمية، الابتكار المفتوح، أنشطة الابتكار، البحث والتطوير، المؤسسات الصناعية الجزائرية.

التصنيف JEL: O30، O32، O33، L60

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Introduction:

Current business realities, immersed in a completely globalized world, have forced organizations to promote, establish and adequately manage innovation processes, taking into account both internal elements and those present in their environments. In this context, communication is assumed to be the leading force that drives innovation because it allows finding sustainable solutions and makes it possible to respond to the needs of markets and societies. Thus, innovation is a driving force for competitiveness in organizations and a promoter of growth in countries.

Traditionally, companies have developed and managed their innovation activities under closed models, from their Research and Development (R&D) and Innovation processes, with their resources and knowledge. However, the challenges in costs and time to successfully carry out the process of transforming an idea into a marketable product or a viable process have given way to a new model of “Open Innovation.”

In innovation management, the open innovation model is considered a paradigm when importance is given to collaborative networks, strategic partnerships, absorptive capacity, and knowledge retention; the values maintained in this model are reaffirmed. With this approach, Chesbrough (2003) argues that organizations, in their external context, can and should take advantage of the innovative ideas, knowledge, and technologies available. Above all, the purpose is to improve product development, offer better services, increase efficiency, and reinforce added value.

The open innovation model has been applied in practices such as crowdsourcing, spin-offs, R&D, etc. This phenomenon has aroused academic interest in studies on open innovation and the co-creation paradigm, in which stakeholders are involved in developing new products (Chesbrough, 2017). In this context and within the current communication ecosystem, information technologies and digital tools become facilitating agents of the relationship between the organization and its environment.

The companies most open to innovation rely on organizational cultures that benefit particular attitudes and capacities such as flexibility, creativity, autonomy, and openness to the environment. These aspects are developed in different lines that allow us to address open innovation practices, more specifically in that which is mediated or supported by digital tools. These tools help business management and enhance competitiveness, innovation, and sustainability strategies. For this reason, the analyzed effects of digital tools on open innovation and business performance must be considered.

Taking into account the lack of empirical studies on how these tools can foster an open innovation process, despite the importance of technological capabilities, the purpose of this study is to analyze the role of digital tools in the Algerian manufacturing industry, as well as the change in their innovation culture. It aims to evaluate the orientation given to digital tools in implementing and promoting open innovation.

This contribution is a starting point towards the roots of open innovation practices, boosted by digital tools and their adaptation to the reality of the manufacturing sector in Algeria. It investigates the adopted open innovation approach, according to its character as an intermediary in innovation systems. The objective is to carry out empirical results about their importance in the innovation process, to establish an open innovation model that will be used to develop this sector. This will allow characterizing the behavior of manufacturing companies regarding the open innovation practices and determining if this behavior acts as a factor driving growth in the Algerian context.

The remaining structure of the paper is as follows. Section 2 reviews the existing literature. Section 3 presents data and methodology. In section 4, the analysis and the interpretation of the results of the empirical study are discussed. Section 5 addresses the paper's conclusions, contributions, and limitations for future research.

I- Literature Review

I-1- Open Innovation

The creation and the development of products and services are becoming more complex, their life cycle is shortening, and there are rapid changes in market demand. These factors are putting increasing pressure on manufacturing companies to develop different capacities and management practices that will help them improve their innovation activities (Rauter et al., 2019). These capabilities include, among others, the so-called “intelligent organization,” which consists of companies learning to use external knowledge and taking care of the environment. The importance of integrating superficial knowledge into innovation activities has been widely recognized in the literature.

Therefore, external knowledge is one of the main factors in the innovation process (Brunswick & Chesbrough, 2018). In this sense, the innovation processes must respond to the public’s expectations since they will be the ones who judge the relevance of business developments. This phenomenon has aroused academic interest in studies on open innovation and the co-creation paradigm, in which stakeholders are involved in developing new products (Chesbrough, 2003).

This concept is regarded in the literature as very important for companies . (Chesbrough, 2003; Chesbrough, 2012) Some researchers and academics consider it to be an overly-ambiguous concept, with a lack of clarification in its process and in the strong influence that suppliers have on the innovation activities.

For manufacturing companies, there are several advantages, including improved innovation activities, improved suppliers’ resource utilization, and enhanced eco-innovation results (Rauter et al., 2019). Open innovation refers to user inputs and outputs of knowledge to accelerate innovation (Chesbrough, 2003). It means that open innovation encompasses collaborative innovation instruments and an innovation management strategy that explores and exploits multiple sources of innovation through multiple channels (West & Gallagher, 2006). This makes knowledge available externally to generate value for innovations through today’s market, new markets, or new businesses.

Several studies have shown, both theoretically and empirically, that open innovation can increase the profitability of companies, return on investment, product innovation, and the probability of success in developing new products (Garcia et al., 2019). Under this context, it is possible to establish that open innovation carried out by manufacturing companies with their suppliers and business partners has significant positive effects on innovation activities.

It can be stated that the more open innovation practices a company establishes, the more the innovation process can be increased. Open innovation practices refer to how open innovation is done by asking the following questions: when, how, with whom, with what objectives, and in what direction innovation activities are carried out, which can be found in various application forms.

By analyzing the existing literature, the open innovation practices include Licensing in, patents acquisition, technology purchase, acquisition of another firm, Co-creation, Outsourcing R&D, university collaboration, E-collaboration tools/social media, Crowdsourcing, Leakage of technology, venturing (Van de Vrande et al., 2009; Scuotto et al., 2017; Chesbrough, 2003).

Open innovation maintains a differentiating approach of openness, collaboration, and strategic flexibility. Human resources primarily use ideas, scientific knowledge, and technology through interaction with external sources (clients, users, suppliers, universities, research centers). This interaction is carried out through incoming flows (incoming open innovation strategy) from external sources with which we collaborate through networks and digital tools to explore search and acquire technical knowledge: scientist, machinery,

equipment and software, and suppliers that provide the necessary tools for the development of new products, services, processes, and methods.

I-2- Digital tools and Open Innovation

Several studies suggest a relationship between innovation, productivity, access, and the use of technological tools. However, this relationship is not easy to identify, and, in Algeria, there is little empirical research on the case. Computing power with technology and growing information access through the digital tool improve companies' management and organizations. Digital tools, therefore, provide innovation and creativity and, through technological advances, are integrated into technological progress.

These tools are essential in the competitive consolidation of companies (Grazzi & Jung, 2016). Information technologies support business management; this can construct competitiveness, innovation, and sustainability strategies, ultimately impacting society. The use of information technologies can improve business performance by speeding up communication and information processing, which can help reduce costs related to decision-making. In addition to restructuring the company, technologies can make processes more flexible and rational and improve communication channels with suppliers and customers, increasing the company's capacity for open innovation (Grazzi & Jung, 2016; Sedkaoui & Moualdi, 2020).

Therefore, open innovation brings with it the challenge of managing all participants and the digital tools that interconnect them. Digital tools seem to function as facilitators that allow companies to use new business processes and practices and improve their performance, but this is more often evident in companies that invest in organizational change processes and human capital. These investments increase absorption capacity and maximize the real impact of new technologies (Grazzi & Jung, 2016).

To identify the role of these tools in open innovation, we must start from the concept of Schumpeter (1934), according to which innovation is defined as the ability to use knowledge to develop and apply new ideas resulting from changes in production and organizational structure. However, these technologies are responsible for the fundamental shift work has had in organizations and doing business in a globalized world. They create a challenge for companies in several countries.

Therefore, investment in innovation includes resources allocated to research and development (R&D) and those used to acquire intellectual property rights. Within these used resources, the use and destination of information technologies should also be considered. Lundvall and Nielsen (2007) believed that digital tools guide collaborative knowledge development and increase the agility of interactive learning. Thus, the possibilities of knowledge transfer, assimilation, and exploitation are increased and codified.

There are two types of flexibility that encourage investment and the use of information technologies to adopt a more open innovation position. The authors describe functional flexibility as the ability of workers to make decentralized decisions and collaborate. In contrast, numerical flexibility refers to cost reduction through outsourcing and extending an external flow of information and knowledge.

Digital tools must be used with respect for the other and a sense of trust in the public's contributions to the construction of new changes. For example, web pages are developed to make organizations visible. It is also a great place to convene audiences in open, collaborative innovation processes because it displays its interests, mission, vision, objectives, philosophy, and history. Also, to implement any participation or collaborations mechanism, it is necessary to have a digital platform that supports companies and allows them to have certain specific functionalities.

Large international companies such as Audi and Microsoft are stimulating the creation of online communities, mainly consumers, to broaden their understanding of their products and open the discussion about new lines of business. Empowered by social networks, people are drawn to this online community and want to join their fields of interest to develop a new

idea. These are efforts of co-creation or open innovation facilitated by technologies that enrich the interaction process between customers and companies and constitute a valuable value creation source (Bugshan, 2015).

In addition, it can be asserted that, in modern economies, digital tools favor the development of new processes, can facilitate internal restructuring, make processes more flexible, reduce capital requirements and reduce inventories. Digital tools and capabilities can also facilitate external communication with suppliers, clients, and other companies and exchange knowledge (Sedkaoui & Moualdi, 2020).

II- Methodology

The study focuses on the Algerian Manufacturing sector, located in Algiers, which was considered suitable for the development of the study due to its level of innovation (Sedkaoui & Moualdi, 2020). According to the World Bank data, the sector has an average value-added of 48.34 billion dollars between 1999 and 2019, and the latest value from 2019 is 40.78 billion dollars which refers to 23.83% of GDP. This value is used to show the importance of the manufacturing sector in the Algerian economy.

For the development of the research study, quantitative research has been chosen, using the survey as the information collection method. A census of companies operating in the manufacturing sector was drawn up to identify the population under study. Using the data from the national statistics office and the Ministry of Industry and PME's annual report (2020), we identified almost 280 manufacturing companies in Algiers¹.

The survey for the collection of information was applied to a sample of 150 innovative companies, located at Algiers, selected by simple random sampling, with a maximum error of $\pm 4\%$ and a level of reliability of 95%; the final sample was made up of 68 manufacturing companies, representing 45.33% of the total. The data shows that only 60% had a website, and less than 43% had active participation on social networks. Therefore, the attention was conditioned to the innovative companies using digital tools.

This paper focuses on analyzing the degree of use and the perception of the utility of consumers, suppliers, and others in developing new products through different technological tools. Therefore, the analysis aims to classify companies based on their level of innovation and the participation of other parts. A combination of the following typologies is used for the questionnaire: A five-point Likert-type scale, multiple-choice, and dichotomous questions.

The questionnaire is divided into three parts (General information, Innovation approach, and Digital technologies' uses and their effect on open innovation) made up of a series of indicators around which the questions are grouped. Most of the scales are based on the literature review, which provides reliability to the questionnaire. The reliability and validity evaluation was applied using Cronbach's alpha and the Composite Reliability Index with the support of the SPSS software.

Table n°1: Internal consistency and validity analysis

Axes	Alpha Cronbach	CR	AVE
ICT Infrastructures	0.825	0.801	0.653
Innovation Approach	0.935	0.947	0.719
Open innovation	0.941	0.942	0.699
Digital tools s and innovation activities	0.781	0.787	0.648
Digital tools and open innovation	0.676	0.679	0.510

Source: Authors elaboration based on SPSS outputs

¹ It should be mentioned that the empirical study did not focus on a particular business group or associations.

The results indicate that Cronbach's alpha and Composite Reliability values are all above 0.6, which provides evidence of the validity of the questionnaire and justifies the internal reliability (Hair et al., 2014)

Table 1 shows a high internal consistency. The composite reliability represents the variance extracted between the group of observed variables and the fundamental construct (Fornell & Larcker, 1981), for which a Composite Reliability greater than 0.60 is considered acceptable. The average Variance Extracted (AVE) was calculated, and the values range from 0.510 to 0.719. These results are above 0.5, as recommended by Fornell and Larcker (1981).

III-Results and Discussions

The use of different digital tools such as email, websites, and social networks, is of great importance for the manufacturing companies which want to take advantage of the functionalities provided by information technologies. These tools present the key factors and the relationship window that companies can use to communicate with their environment or the public (consumers, suppliers) who can participate in the innovation process.

The results are more optimistic since more than 67% of the surveyed companies invest in hardware and software. Almost 86% use email to communicate with customers and suppliers, and 48.56% of these companies allow customers and users to include their inquiries and comments about products or services. The manufacturing sector needs to remain competitive.

The descriptive statistics in Table 2 about the various implications of information technologies indicate that the perception regarding their role was above the average since the total value reached 3.43, with a standard deviation of 0.635.

The results show that information technology allows creating an effective working environment through facilitating knowledge sharing between employees and the company's different departments. They also enable data collection and uses, as well as reducing the time of completing operations. Regarding the communication with consumers and suppliers, the results were medium. It means that manufacturing companies began to implement open innovation as a necessary organizational adaptation to changes in the environment by allowing access to knowledge not available internally.

Table n°2: Descriptive statistics

Items	Mean	St dev	Level
Communication between employees	4.15	0.396	High
Communication between different departments	3.72	0.947	Medium
Communication with consumers	3.13	0.845	Medium
Communicate with suppliers	3.21	0.703	Medium
Data storage, access, and use	3.96	0.438	High
Knowledge sharing	4.18	0.384	High
Reduce time	3.79	0.475	High
Reduce costs	2.81	0.673	Medium
Contributing to production processes	1.93	0.852	Low
Total	3.43	0.635	-

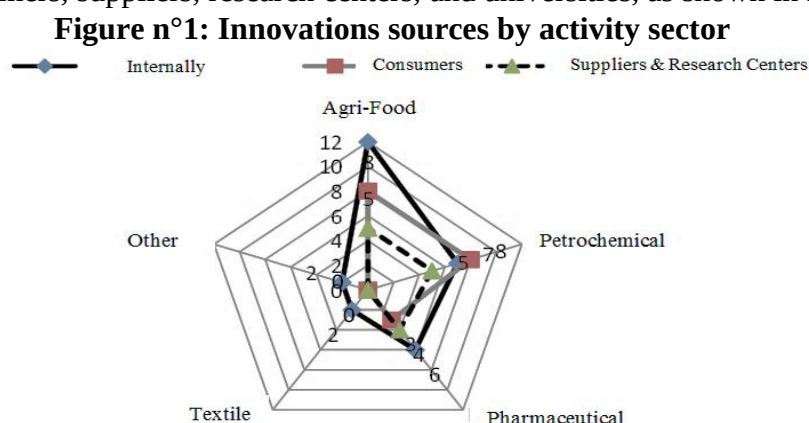
Source: Authors elaboration based on SPSS outputs

It should be mentioned that many companies are collecting data, but that does not mean they are using it effectively since the amount of data available often exceeds the installed analysis capacity. The lack of qualifications and capacity, resources, and adequate information and communication technologies (ICTs) infrastructure are the biggest obstacles in this regard.

In addition, results show that surveyed companies do not see these tools can help reduce costs and improve the different production processes, even if they consider this tools an essential part of their daily routines.

It will be necessary also to highlight the variables that explain the innovation behavior in manufacturing companies. Globally, all surveyed companies have realized a set of changes in their products or services, their production processes, marketing methods, or even their organizational working method. The aim is to identify these companies' goals by adopting an innovative strategy and integrating digital tools in the different innovation activities.

This set of changes that have improved and developed the innovation activities rely more on the internal source of knowledge (employees) and external knowledge provided, from their consumers, suppliers, research centers, and universities, as shown in Figure 1.



Source: Authors elaboration based on data analysis with Excel

It seems that the Agri-Food sector, Petrochemical sector, and the pharmaceutical sector depend more on internal sources or the available information and the skills and knowledge of their employees. However, customers are a primary source of new ideas for manufacturing companies. They also work alongside other enterprises, such as suppliers and research centers. The results of correlation analysis indicate that the use of some digital tools is correlated with innovation activities and the open innovation strategy.

The correlation results shown in Table 3 indicate that innovation positively correlated with the existence of websites (0.684), the investment in hardware and software (0.513), and the use of emails (0.513). However, open innovation is correlated only with websites (0.637) and the use of email (0.466).

Table n°3: Correlation matrix

		Inn	Open Inn	Web	Invest H/S	Email	Platfm	Soc Net
Inn	Coeff	1						
	Sig.							
Open Inn	Coeff	.647*	1					
	Sig.	.012						
Web	Coeff	.684**	.637*	1				
	Sig.	.000	.011					
Invest H/S	Coeff	.513*	.150	.338	1			
	Sig.	.017	.405	.054				
Email	Coeff	.513**	.466*	-.187	.285	1		
	Sig.	.002	.036	.296	.108			
Platfm	Coeff	-.161	.287	.319	.157	.148	1	
	Sig.	.372	.106	.071	.382	.411		
Soc Net	Coeff	-.061	-.048	.241	-.045	.020	-.115	1
	Sig.	.735	.790	.176	.805	.912	.523	

*. Correlation is significant at the 0.05 level (2-tailed).

****.** Correlation is significant at the 0.01 level (2-tailed).

Source: Authors elaboration based on SPSS outputs

So, it is essential to consider that emails, websites, and some digital tools, which capture and exploit knowledge, are part of the determining activities for successful open innovation practices, which provide competitive advantage and increase efficiency. Therefore, changing the collection, analysis, and protection of external and internal data and knowledge (Sedkaoui, 2018).

In addition, innovation processes involve various activities at the operational and management levels and require different support means. Web tools help to systematize and structure activities and information flows, making them more efficient in terms of resources and more effective in terms of results. Regarding the use of social networks and the different digital platform, results show that these two essential means are not considered by surveyed companies as a factor to improve their innovation approach.

However, social networks and free software can reduce ICT costs (Berger & Thomas, 2014). These tools allow effective communication inside and outside the company (Sedkaoui, 2019) and support functional areas such as marketing, sales, accounting, production processes, and human resource management (Spiezia, 2011; Sedkaoui & Moualdi, 2020)

The correlation matrix also indicates that an internal consistency positively correlates between open innovation and innovation activities (0.647). Therefore, systematically encourage and explore a wide range of internal and external sources, allowing companies to improve their innovation potential. Then, it is essential to integrate this exploration process with the company's capabilities and resources and extensively exploit those opportunities through multiple channels.

Rauter et al. (2019) found that open innovation has a significant positive impact on different innovation activities, which leads to an increase in the level of performance of manufacturing companies as a whole. Additionally, for manufacturing companies to properly implement innovation activities, they require the collaboration of consumers and suppliers, and other companies and organizations. Therefore, open innovation is one of the most important alternatives emerging as a strategy for achieving innovation.

This corroborates what has been stated so far on open innovation, favoring novel schemes that lead to the participation of other agents of the innovative process and clarifying those internal and external collaborators participate in this environment. It is therefore relevant to investigate the main factors that influence a companies' tendency to innovate.

Table 4 shows the factor analysis results based on the variables correlation matrix because it allows measuring the relationship between variables. Using factor analysis for this study was confirmed by Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy.

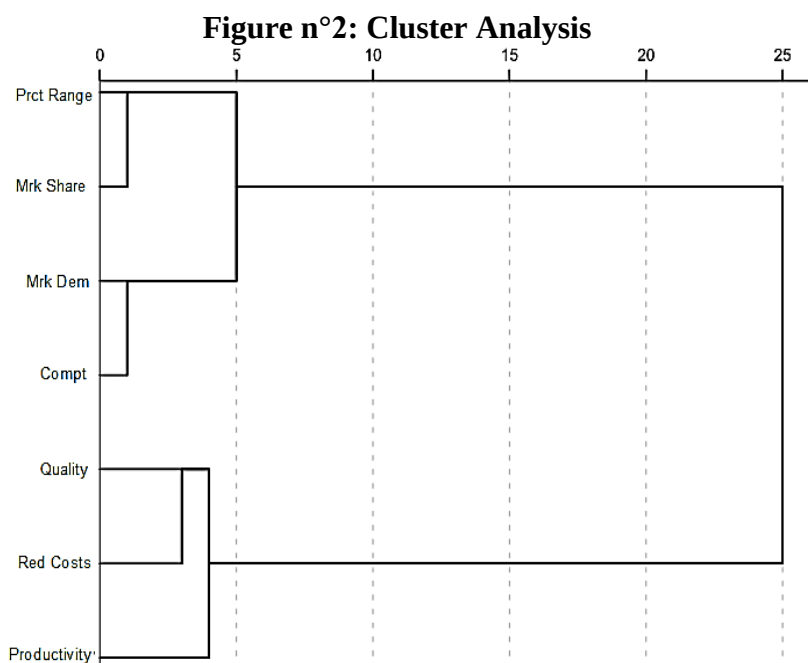
Table n°4: Rotated Component Matrix

Goals	Components	
	Factor 1	Factor 2
Market demand	.170	-.567
Product range	.836	-.159
Market share	.911	-.125
Competition	.726	.094
Quality	.122	.718
Reducing Costs	-.346	.784
Productivity	.075	.732

Source: Authors elaboration based on SPSS outputs

Data were considered suitable for analysis based on the KMO measurement value of 0.753. Bartlett's test of sphericity shows that the probability value was less than 0.001.

The results indicate that the goals can be divided into two categories. The first includes the factors related to competition and the market: diversification and expansion of the range of products, meeting market demand, achieving competitive priorities, and growing market share. The second is related to product development, such as enhancing the quality, reducing costs, and increasing productivity. Important factors in determining the degree of innovation activities are related to the market and competitiveness conditions that promote companies to develop new products or processes.



Source: SPSS outputs

In this sense, we will establish a classification of companies that also allow us to contrast if there is a direct relationship between the orientation to innovation and their levels of success in achieving these goals. This approach leads us to define cluster analysis as the most suitable statistical method. Cluster analysis presented in Figure 2 gives a detailed vision of the previous factors that can influence the open innovation orientation in the companies.

The motivations to get involved in open innovation can range from wanting to solve technical problems (pharmaceutical companies are the ones that most frequently do so) to carry out broader market research on products and services. Most of the mutual benefits that can be derived from the practice of open innovation are improvements in production processes, enhancements in product functionality, and accelerated market entry.

In this context, the interrelationships with consumers and suppliers are increasingly crucial for manufacturing companies. More than 70% of surveyed companies (see Figure 1) state that they rely on external ideas in their innovation activities.

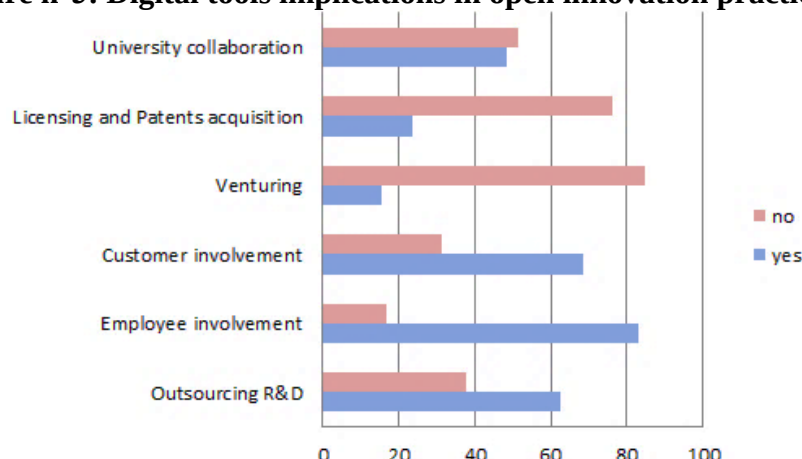
Agri-food, Petrochemical, and Pharmaceutical companies are identified more with relationships with suppliers, customers, and research centers. From Figure 3, we can see that manufacturing companies are embracing ICT benefits to improve their open innovation practices. Open innovation frequently leads to the acquisition of other companies, the purchase of patents, or the use of licenses for materials, processes, etc.

When it comes to acquiring a company, results show that it is not very common to do so if the company's technology is outside the area of competence of the acquiring company, or this is a company dedicated to the integration of technology. In these circumstances, the creation of a joint venture is more common.

Figure 3 reveals that open innovation occurs in Algerian manufacturing companies as a result of customer and employee involvement, as well as R&D services purchasing from other companies (universities or suppliers), which is confirmed and supported by previous studies

(Van de Vrande et al., 2009). However, the implication of digital tools in venturing, in particular, is less prominent. Licensing and Patent acquisitions provide additional evidence open innovation approach supported by information technologies.

Figure n°3: Digital tools implications in open innovation practices



Source: Authors elaboration based on data analysis with Excel

The traditional innovation model collects the companies' knowledge and information in developing countries with no risk intellectual property. Instead of obtaining collaboration and opportunities in markets that allow flexibility and open and dynamic businesses, they work in competition. The only alliances that could be given are customer and supplier, which is possible with a previously established contract.

As this study analyzes the effect of digital tools on the open innovation approach, a hierarchical regression analysis was conducted. For this, tolerance and variance inflation factor (VIF) are used to assess multicollinearity between variables. Tolerance values ranged from 0.166 to 0.890 (above 0.05), and VIF values were below 4 (between 1.124 and 3.661).

Table n°5: Hierarchical regression results of digital tools and open innovation

Variables	β	t	p-value
Hardware and Software	.058	.445	.660
Website	.707	5.275	.000
Digital platform	.095	.706	.486
Social networks	.051	.398	.693
$R^2 = 0.479$		$F = 13.804$	

Source: Authors elaboration based on SPSS outputs

This regression analysis considers the effect of Hardware and Software, website, digital platform, and social networks since these factors significantly influence companies' open innovation initiatives.

The analysis was significant ($F = 13.804$, $p < 0.01$). The regression results indicate that only the website was significant ($\beta = .707$, $p < 0.01$) and explained 47.9% of the variance of the open innovation. Results show that only one factor among many digital tools enhances the open innovation approach in the Algerian manufacturing companies. Therefore, the first contact with public participants in the open innovation approach is made via its website, which refers to its primary communication channel.

However, it should be noticed that the surveyed companies are convinced of the importance of digital tools since they allow and facilitate the contribution of the consumer and suppliers in the innovation process. In this sense, several studies show that information technology has contributed to the implementation of open innovation models and the virtualization of the innovation process (Sedkaoui, 2019, Dogson et al., 2006; Sedkaoui & Moualdi, 2020).

Along these lines, it is essential to consider what is understood by investment in innovation since innovation is not limited to creating new products. All business changes are subject to the allocation of resources: physical, human, and financial. Although companies have significant experience in digital managing tools to improve productivity, they have traditionally failed to leverage these tools to achieve participation and knowledge exchange. These tools are vital since collective intelligence makes sense with the interconnection of individuals through new digital possibilities.

Conclusion

This paper aimed to articulate the conceptual bases of an analytical framework to study the effects of digital tools on the open innovation approach. The intended result was achieved based on an in-depth review of the relevant literature in the field. The literature shows that relatively few empirical research studies link digital tools and digital technology with open innovation than studies on their conceptualization.

The empirical analysis applied in this paper has generated a positive correlation between digital tools, innovation activities, and open innovation. This analysis allows developing an overview of innovation activities in manufacturing companies in Algeria. According to the results, ICT architecture that allows the fluid exchange of knowledge should be built; this will be especially useful in searching for new external knowledge strategies.

Results confirm that in technology-based industries, such as the pharmaceutical industry, the lack of digital tools presents a severe limitation to the innovation process and, as a result, to the integration of global knowledge production chains. Algerian manufacturing companies should, therefore, evaluate the importance of acquiring information technologies' tools that can support the innovation process. Regarding this point, Algerian companies need to continue moving forward with open innovation by implementing advanced mechanisms that facilitate the management and the use of communication flows and increase the ability to achieve strategic objectives.

The results obtained in this empirical study have different implications for companies and the country in general. The paramount importance derived from the results is that the data emanating from the application of some Algerian manufacturing companies allowed a global analysis of the relationship between open innovation, digital tools, and innovation activities. The adoption and implementation of digital tools and the analysis of their effects on open innovation practices in Algeria have not been explored in the literature; therefore, this study provides theoretical and empirical evidence about the relationship between these concepts.

Another implication of the study is that more and more manufacturing companies are implementing open innovation as a business strategy to share resources, knowledge, and skills to improve their innovation process (Garcia et al, 2019). Therefore, open innovation is becoming a basic strategy that significantly positively affects innovation activities and business performance (Arnold, 2017).

When analyzing and interpreting the results of this study, it is necessary to consider some inherent limitations. Some of them related to using the measurement scales of open innovation and digital tools since they were measured through subjective indicators obtained from survey data. Therefore, future studies will require incorporating various objective data from manufacturing companies, such as the number of collaborative projects with business partners, number of collaborative innovations, IT investment, percentage of technologies' uses, etc.

In addition, a moderating variable based on the characteristics of companies (size, sector) or managers (experience, skills) can also be incorporated into the analysis of open innovation practices enabled through digital tools. Further, a consumer's point of view should be considered in a future research area to show that the participation required is also a valued element and an essential factor. Also, the set of Algerian manufacturing companies analyzed

constitute an approximation to the measurement of the effectiveness of digital tools as an open communication channel on company innovation activities, expanding the field of research started by analyzing the 2.0 area from this perspective.

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