

INNOVATION IN THE ALGERIAN ELECTRONICS INDUSTRY: INTERNAL STRATEGIES AND ECOSYSTEM LIMITATIONS

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Abstract

Innovation is generally understood as a collective process, embedded in networks of actors through which knowledge is co-created and transformed into innovation. This article aims to examine the development of innovation in the electronics industry in Algeria and its relationship with the sector's innovation ecosystem. The study adopted a quantitative, survey-based approach targeting firms in the electronics sector across multiple regions of Algeria. Data were collected using a structured questionnaire administered to 150 firms, of which 70 valid responses were obtained from four major geographical areas of the country. The study results reveal the existence of innovation practices within Algerian electronics firms. Although referred to by different labels, innovation primarily takes the form of solutions to internal organizational, technical, or market challenges. These innovations are used as part of a survival and sustainability strategy. While the environment influences innovation by providing knowledge and opportunities, the development of sustained innovation ecosystems remains limited, as it is constrained by many structural challenges. As a result, firms tend to view innovation mainly as an endogenous and internal process.

Keywords: Innovation, Firm, Ecosystem, Electronics industry, Algeria.

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1. INTRODUCTION

In a knowledge-based economy characterized by intense competition and rapid technological change, innovation is a key driver of competitiveness (Agazu & Kero, 2024; Koç et al., 2026). In this context,

innovation enables firms to adapt to rapidly changing environments and refers to the process of introducing and implementing new ideas, products, or processes to create value and beneficial outcomes (Kochetkov, 2023; Stundziene et al., 2024). Furthermore, the innovation process is generally embedded in complex ecosystems of interacting actors that enable knowledge creation and dissemination (Granstrand & Holgersson, 2020; Silva et al., 2024). However, in some sectors or contexts, innovation is difficult because interactions among these actors are weak or poorly organized.

From this perspective, the development of innovation relies heavily on the creation and continuous reinforcement of knowledge capital, defined as the collection of information and scientific and technical knowledge that a firm or a group of firms produces, acquires, combines, and organizes for productive purposes (Cabrilo et al., 2024). This dynamic capital serves as the foundation for creating value, enabling firms to innovate and to sustain their competitiveness in rapidly evolving markets (Laperche, 2021; Laperche & Liu, 2013). Consequently, firms must develop their knowledge capital through a collective process within a larger ecosystem, by creating a collaborative network with multiple actors, including competitors, universities, research centers, and customers (Chesbrough, 2003).

Innovation plays a vital role in competitive sectors such as the electronics industry, as it enables firms to survive, maintain a competitive edge, and stimulate sustainable growth. In this context, continuous innovation not only addresses immediate market and organizational challenges but also helps firms position themselves strategically for long-term development. This challenge is particularly evident in Algeria, where many firms in the electronics industry face increasing difficulties in maintaining their market position.

This article examines the reality of innovation in the Algerian electronics industry and explores the extent to which firms' innovation ecosystems support the collective construction of knowledge capital and its transformation into various forms of innovation. The development of an innovation ecosystem raises the question of how effectively such ecosystems are actually established and sustained. Recognizing that innovation is not merely a creative act but a complex process of interaction among multiple partners leading to open innovation, the durability of these interactions is often uncertain. This leads to the question of whether innovation should be understood primarily as an endogenous process within the firm rather than as an outcome of external interactions. This question is particularly relevant in the Algerian context, where innovation ecosystems are still developing and interactions among their actors remain weak. Accordingly, this study examines an underexplored innovation ecosystem in the Algerian electronics sector, providing insights into an environment characterized by weak external support.

This article is divided into two parts. The first part is theoretical and focuses on the concept of the innovation ecosystem, which integrates systemic linkages to foster open innovation. Specifically, it aims to define the concept of the innovation ecosystem and discuss its complexity. The second part is empirical

and presents, based on field research, the nature of innovation development and the reality of the innovation ecosystem of Algerian electronics firms.

2. THE TRUE NATURE OF THE INNOVATION ECOSYSTEM

The metaphor of the "ecosystem" was borrowed from the field of biology and used in organizational studies and management to refer to a dynamic set of actors interacting with one another (Mars et al., 2012). In the context of innovation, the main role of an ecosystem is to support and facilitate the complex innovation process (Koenig, 2013). Innovation is therefore not a simple act of creation, but rather a process involving multiple interactions among different actors. Accordingly, innovation is a complex process of interactions leading to the systematization of relationships between different partners engaged in the act of innovation (Powell et al., 1996; Yousefikhah, 2017). This relational nature of innovation ecosystems also distinguishes the concept from other closely related approaches, such as innovation systems, business ecosystems, and knowledge capital, which correspond to different levels and perspectives of analysis.

The concept of an innovation system can be examined at the national, regional, and sectoral levels and seeks to understand how a country generates innovation and how its innovation system functions. The analysis primarily adopts an institutional perspective, focusing on the policies and frameworks that govern interactions among universities, firms, and public organizations (Edquist, 2006; Lundvall & Johnson, 1994). By contrast, the concept of an innovation ecosystem focuses mainly on the meso level and adopts a relational perspective, focusing on how actors collaborate to co-create and diffuse innovation (Chesbrough et al., 2024). It therefore emphasizes interactions, knowledge flows, and relationships of collaboration and trust among different actors and institutions.

The concept of a business ecosystem is more closely associated with a micro-level analysis, focusing on the firm and how it develops partnerships and makes strategic choices. Introduced by Moore (1993), the business ecosystem concept places the firm at the center of a network of suppliers, customers, and partners, with whom it develops complementary and collaborative relationships to create a competitive advantage. Finally, knowledge capital explains how knowledge can be transformed into value and innovation through human, structural, and relational capital (Wright et al., 2014).

This process often involves collaboration with external actors. Firms operating in knowledge-intensive or high-technology sectors frequently collaborate with research and academic institutions to develop their knowledge capital and transform it into innovation (Etzkowitz & Leydesdorff, 2000). In this regard, the term knowledge capital refers to an economic intelligence activity (Laperche & Liu, 2013). The firm builds its

knowledge capital through research and the acquisition of scientific, technical, and commercial information, which may enrich, shape, and systematize internally produced knowledge (Siesfeld et al., 2009). From this perspective, a firm's knowledge capital emerges not only from the scientific and technical knowledge it develops but also from its interactions with multiple actors (Laperche, 2021; Laperche & Liu, 2013). Finally, firms engage with other stakeholders, including governmental, financial, and regulatory bodies, as well as competitors, with whom they may establish cooperative or competitive arrangements (Gulati et al., 2000). However, despite generating increasing interest in the academic sphere, the concept of innovation ecosystem remains the subject of a complex debate that challenges its consolidation as a fully established theory of organizations (Hess, 2010; Tsujimoto et al., 2018). In this sense, it can be argued that innovation, whatever its nature, arises within an ecosystem nourished by both proximate and distant interactions among diverse actors. These actors are highly diverse in nature, forming a system that tends to maintain its balance throughout its evolutionary phases (Granstrand & Holgersson, 2020). Despite this openness to the external environment, this does not mean that the firm is subject to and overwhelmed by its social milieu. The firm maintains its own social unity and possesses a structure with original traits that are not ephemeral (Hatch & Schultz, 2002). This social unity leads to the creation of an internal mindset within the firm. More precisely, firms embody a system of values, norms, and cognitive frameworks that shape perceptions and behaviours both internally and externally (Serrat, 2017; Tadesse Bogale & Debela, 2024). Since this study examines both organizational capabilities and interactions among firms, universities, and public institutions, the innovation ecosystem perspective provides the most appropriate theoretical lens.

3. METHODOLOGY

The study adopted a quantitative research approach, with data collected through a structured questionnaire. According to reports from the Algerian Ministry of Industry and Mines, the electronics and home appliance sector comprises 933 firms. Therefore, the survey targeted electronics firms across 18 wilayas (Algeria is administratively divided into wilayas or administrative provinces), using data from the CNRC (National Center for Trade Registry) and Kompas Algeria databases. Based on these data, a simple random sampling procedure was adopted, with 150 firms selected through a random draw, each having an equal probability of selection. To ensure that the sample covered only firms operating in the targeted subsector (manufacturing, assembly, and installation), the companies' websites were reviewed to verify their activities and exclude those operating in related subsectors, such as equipment sales. The contact details of the targeted firms were verified through Internet searches and/or direct telephone contact. Once the final list was established, the firms were informed through personalized letters addressed to their top executives, outlining the study's purpose and objectives, the expected participation,

the identification of a contact person responsible for completing the questionnaire, and the planned visit of the researcher to collect the required information.

Despite all precautions taken to maximize the response rate, the on-site survey resulted in 70 exploitable questionnaires, representing 46.6% of the targeted sample. Although the sample size is relatively modest and the findings may not be representative of all firms, it is appropriate for an exploratory study of a specific and relatively small industrial sector in Algeria. The respondents are directly involved in innovation activities, which strengthens the relevance of the data collected. As with any survey-based study, response bias cannot be entirely excluded. To reduce this risk, anonymity and confidentiality were ensured throughout the survey process.

The responses were distributed across fourteen wilayas, as presented in Table 1.

TABLE 1. DISTRIBUTION OF QUESTIONNAIRES BY REGION

Regions	Wilayas	Number of questionnaires	(%)
East	Batna, Béjaïa, Tébessa, Sétif, Annaba, Bordj-Bouararidj	22	31.5
Center	Algiers, Tizi Ouzou	28	40.0
West	Tlemcen, Sidi Bel Abbes, Oran	11	15.7
South	Ouargla, El Oued, Ghardaïa	9	12.8
Total	—	70	100

Source: Authors' compilation

In terms of size, small and medium-sized firms (SMEs) prevail, accounting for 78.6%, as shown in Table 2.

By contrast, the remaining 21.4% are large firms with varying workforce sizes.

TABLE 2. DISTRIBUTION OF FIRMS BY SIZE

Firm size	Number of firms	(%)	Employees
Small & Medium (SMEs)	55	78.6	10 – 250
Large Firms	15	21.4	250+

Source: Authors' compilation

TABLE 3. BREAKDOWN OF LARGE FIRMS BY WORKFORCE SIZE

Workforce size	Number of firms
1000+	4
500 – 1000	5
251 – 500	6
Total	15

Source: Authors' compilation

This study adopted a quantitative research approach to examine innovation practices and ecosystem dynamics within the Algerian electronics industry. More precisely, it sought to understand the internal innovation strategies of the investigated firms, as well as the challenges and opportunities posed by the broader innovation ecosystem. Regarding the development of the questionnaire, it was initially based on exploratory semi-structured interviews conducted with a number of firms, combined with a conceptual analysis of the study variables to identify the indicators for empirically examining the phenomenon under

investigation. Subsequently, the questionnaire was pre-tested and validated with five targeted firms, three located in the Wilaya of Algiers and two in the Wilaya of Sétif.

Following this process, data were collected using a structured questionnaire divided into three main sections (Table 4).

TABLE 4. QUESTIONNAIRE STRUCTURE

Sections	Content
Firm profile	– Firm size, workforce, type of products or services manufactured, etc.
Innovation practices	– Types of innovation implemented – Mechanisms supporting innovation: internal innovation committees, brainstorming sessions – Openness to innovation and the presence of dedicated structures for managing innovation processes
Innovation ecosystem and knowledge sources	– Partnerships and collaborative relationships – Sources of information and knowledge – Assessment of difficulties in maintaining interactions with ecosystem actors

Source: Authors' compilation

Multiple-choice questions were used to allow firms to report several mechanisms or innovations simultaneously. A nine-point scale was used to evaluate the degree of difficulty of interactions with ecosystem actors, ranging from "minor difficulty" to "critical difficulty."

The survey was conducted on-site. Each questionnaire was personally administered to managers or executives responsible for innovation within their firm. Prior to completion, the concept of innovation was clearly explained to respondents to ensure a consistent understanding, as many firms did not explicitly use the term "innovation" internally.

The collected data were cleaned and analyzed. In particular, descriptive statistics were used to:

- Determine the frequency of different types of innovation (organizational, process, product and marketing).
- Identify the mechanisms and structures supporting innovation within firms.
- Rank knowledge sources by importance, reflecting their role in supporting innovation.

Concerning the nature of economic activities, the majority of surveyed firms (58.6%) operate in the manufacture of electrical and home appliances, including consumer electronics, electrical equipment, and refrigeration systems. This predominance likely reflects the relative size and demand characteristics of the domestic market. Meanwhile, 17.1% of firms are engaged in the production of medium-voltage cells, electrical cable harnesses, telecommunications equipment, electrical cabinets, fiber optic telecom cables, and the manufacturing and installation of telecommunication networks.

Finally, the remaining firms (24.3%) specialize in precision equipment manufacturing, including computers, solar panels, elevators, and refrigeration and safety systems.

4. RESULTS AND DISCUSSION

4.1 Innovation: a strategy for sustainability

Despite environmental and market challenges, Algeria's electronics industry is working towards sustainability through initiatives aimed at improving its market positioning. In this context, innovation is a key strategy for maintaining its presence in the market and increasing the perceived value of its offerings. Hence, the initial contacts with electronics firms revealed that innovation is present in product development, manufacturing processes, organization, and marketing.

However, in many cases, the term "innovation" is not explicitly used but is instead framed under alternative labels. Notably, during the field investigation, the concept of innovation was explained to firm managers based on the definition provided in the questionnaire. Subsequently, it became evident that many of the mechanisms and practices implemented by firms naturally aligned with this definition.

Regarding firms' openness to innovation, the results indicate that the vast majority (92%) report being receptive to innovation-related initiatives. Furthermore, concerning the institutionalization of innovation practices, two-thirds of the firms (67.1%) stated that they had implemented dedicated mechanisms to manage innovation processes. It should be noted that, because this question allowed multiple responses, firms often reported the presence of more than one mechanism. When analyzed by firm size, small and medium-sized enterprises (SMEs), with between 10 and 250 employees, appear to be the most equipped with innovation support mechanisms (61.9%). This finding may be related to the flexibility and organizational dynamism typically associated with SMEs. In other words, SMEs demonstrate greater responsiveness in adopting mechanisms that promote innovation, enabling them to adapt more rapidly to market demands and implement improvements in organizational and operational processes.

TABLE 5. INNOVATION TYPES

Innovation dimension	% of actions	Main mechanisms
Organizational	29.6%	Internal committees, brainstorming sessions, monitoring units
Process	28.9%	Improvement of methods, logistics, maintenance
Product	21.5%	New product versions, incremental improvements
Marketing	20.0%	Packaging, distribution (direct/online)

Source: Authors' compilation

Among the mechanisms identified, 55.3% of firms favored internal innovation committees and brainstorming sessions. Meanwhile, 44.6% established monitoring or surveillance units, whereas suggestion boxes were implemented by only 23.4% of firms, indicating that these mechanisms were less commonly used. Collectively, these mechanisms highlight the importance of structured internal processes in fostering continuous improvement and facilitating knowledge sharing. With respect to innovation types, managers appear to prioritize organizational innovation, accounting for 29.6% of all innovation-related actions (Table 5). This is closely followed by process innovation, which accounts for 28.9%. This distribution appears consistent with the need for firms to simultaneously enhance organizational efficiency

and production performance. Product innovation ranks third (21.5%), while marketing innovation occupies the fourth and final position (20%). Notably, marketing-related innovations are primarily linked to product enhancement strategies.

The attitude of industry players towards innovation activities seems to be constrained by both the nature of the electronics industry, which is characterized by high rates of obsolescence and the market in which they operate. The market is segmented by products of varying quality and, in particular, by price competition: products imported from different countries, products sold in parallel markets, and products available on second-hand markets. The survey revealed that, given the instability of the electronics product market, firms need to engage in innovation activities to maintain their market position. Furthermore, they need to respond to increasingly demanding consumer needs in light of the evolving nature and quality of products available on the market. Therefore, for electronics firms in Algeria, innovation becomes a means of sustainability and even a struggle for survival. In Algeria, firms in this sector innovate primarily to survive in an environment that does not necessarily foster innovation. This innovation focuses on preserving market share and enhancing existing offerings, rather than seeking radical novelty. Any changes to these offerings, particularly through incremental innovations, require assurances regarding its commercialization. Moreover, the manufacturing process is affected by innovation, while marketing and organizational innovations remain mostly internal to the firm.

4.2 Collective innovation through necessary partnership relations

Innovation is a complex process in which interactions among multiple actors are essential, transforming the "whole" into a "system" or rather an "ecosystem" (Laperche, 2021). In this sense, cooperation among various actors (firms, universities, research centers, etc.) enables the construction of the firm's knowledge capital, thereby enhancing productivity and enabling collaborative innovation (Chesbrough, 2003). Engagement within the ecosystem is driven by the objectives of open or collective innovation and is reflected in cooperative relationships with various actors (Chesbrough et al., 2024; Huizingh, 2011; Perkmann & Walsh, 2007). This is the case for many electronics firms in Algeria. When asked about the partners with whom the surveyed firms develop product innovations, the results indicate that just under half of the sample, 45.7%, stated that they mainly rely on partnerships with foreign firms and institutions, while only 20% reported that innovation development occurs through collaboration with local firms and institutions. Given that the product represents the company's brand image, particularly in the electronics industry, any change (especially incremental innovations) requires some assurance of successful commercialization. For these firms, engaging with foreign partners constitutes a strategy to maintain or expand their market share.

Regarding process innovation, which includes the introduction or significant improvement of manufacturing and production methods, logistics, delivery, distribution services, or process support systems (e.g., maintenance, procurement, accounting, or IT systems), firms rely more on foreign partners (31.4%) than on local partners (21.4%). However, in marketing innovation, which includes significant changes in product design or packaging and new sales or distribution methods (direct or online), firms also favor foreign collaborations (18.6%) and even fewer local collaborations (11.4%).

Overall, Algerian electronics firms maintain relationships with both national and international partners to sustain their market position. In particular, foreign partnerships are prioritized for developing collective product innovation, followed by manufacturing processes, and finally, marketing innovations. By contrast, only one-fifth of firms engage local partners in collective innovation. It is noteworthy that product and organizational dimensions are the most affected by innovative changes.

4.3 Innovation ecosystem: importance of knowledge sources and fragility of inter-organizational relationships

4.3.1 Importance of knowledge sources

Concerning the perceived importance of knowledge sources driving innovation, managers assign the greatest importance to non-institutional sources, particularly private and open access channels. The ranking of information and knowledge sources reveals that internal sources are perceived as the most important with a score of 8.28. Customers contacted through direct prospecting follow closely (7.52), alongside the internet and computer databases (7.21). Industrial fairs and exhibitions (7.04) and suppliers (6.23) occupy intermediate positions, whereas competitors are considered the least influential source (4.41).

However, the importance scores decline considerably when it comes to institutional actors responsible for producing knowledge and expertise. Consultants rank seventh with a score of 3.45, followed by universities and/or university laboratories in eighth position with a score of 2.85. Patent consultation comes in ninth position with a score of 1.39. In last position, are the public research centers with a score of 1.23 (See Table 6, where missing values result from a limited number of unanswered items and were excluded from the calculation of the corresponding indicators). These results reflect the fragility and instability of the transactional relationship between firms and ecosystem actors, especially those contributing to the production of knowledge and expertise.

The survey revealed that firms in Algeria's electronics industry rely primarily on their internal innovation capabilities to remain competitive in the market. For these firms, this is not merely a strategic choice, but above all an adaptive response to imperfections in their institutional environment and the ineffectiveness of

the innovation ecosystem. Indeed, faced with limited access to external resources and market instability, firms rely mainly on their internal resources and capabilities, which they integrate, reconfigure, and leverage to maintain their ability to adapt, thereby illustrating the concept of dynamic capabilities (Teece et al., 1997; Teece et al., 2008).

TABLE 6. IMPORTANCE OF INFORMATION SOURCES FUELING INNOVATION

Indicators	Score	Rank	Total	Missing
Internal sources	8.28	1	68	2
Customers	7.52	2	68	2
Internet and computer databases	7.21	3	66	4
Trade fairs/industrial exhibitions	7.04	4	68	2
Suppliers	6.23	5	68	2
Competitors	4.41	6	68	2
Consultants	3.45	7	66	4
University laboratories	2.85	8	66	4
Patent documentation	1.39	9	66	4
Public research centres	1.23	10	66	4

Source: Authors' compilation

The limited interactions observed with universities, research centers, and public institutions do not necessarily reflect a rejection of open innovation, but rather the presence of high transaction costs, a lack of effective intermediation mechanisms, and a deficit of institutional trust that constrain the development of lasting cooperative relationships. Although knowledge is available, its circulation and valorization remain limited by administrative constraints and the lack of effective university–industry linkages and technology transfer mechanisms in Algeria, representing a major weakness of the national innovation system (Saad & Zawdie, 2005). Interactions with knowledge-producing organizations are of limited importance, primarily due to weak connections and a lack of institutional intermediation. Although relatively limited in number, several studies on innovation suggest that Algeria lacks an effective national innovation system (Djefflat, 2009). The actors or stakeholders of the innovation system, including central decision-makers, industrialists and entrepreneurs, individual researchers, and research institutions (research centers, research laboratories, research & development centers), are largely disengaged, and each of them works almost in isolation (Djefflat, 2011). This limited circulation of knowledge is compounded by firms' constrained ability to absorb and transform knowledge generated by the research system into innovations, as well as by the need for universities to align their research activities more closely with industrial needs—two dimensions closely related to absorptive capacity (Cohen & Levinthal, 1990; Saad et al., 2017). Under these conditions, the innovation ecosystem appears less as a stable network for knowledge co-production than as a set of sporadic and opportunistic relationships.

Firms do not reject external interactions in general. They cooperate with foreign partners when seeking technological expertise or commercial assurances, but engage far less with domestic knowledge-

producing actors, such as universities, laboratories, and research centers. This does not reflect a dichotomy between internal and open innovation, but rather a selective choice of partners based on their ability to generate immediately exploitable value. In other words, firms develop what can be described as selective open innovation.

4.3.2 Fragility of inter-organizational relationships

Managers were asked to assess the difficulty of direct and indirect interactions with various actors in the innovation ecosystem, which are essential for transforming ideas into implementable innovations. Nine indicators were proposed:

- Two (02) related to the company's interactions with actors in public research.
- Two (02) related to financial actors (banks).
- Three (03) related to regulatory and control actors (market, competition, intellectual property rights, etc.).
- Two (02) related to internal firm constraints (problem of qualified personnel, financial capacity).

For the interpretation of the results, the indicators are ranked according to their difficulty scores in ascending order, with rank 1 corresponding to the lowest difficulty score and rank 9 to the highest. Accordingly, the lack of intermediation with university research laboratories seems to be the least severe obstacle, although it is still perceived as a significant difficulty with a score of 2.07. In other words, these firms suffer from the lack of intermediation with university research laboratories that could support them in innovation activities (Nahla, 2023). Contacts often occur within personal networks rather than institutional frameworks (Guernoub & Benbouzid, 2025).

In second position comes the lack of qualified personnel, which is considered a major difficulty, with a score of 2.37. These firms suffer greatly from this problem as they are not able to retain qualified personnel. Difficulty scores are slightly higher for the two financial indicators. The lack of equity has a score of 2.42, ranking third, while limited access to external capital to support innovation scores approximately 2.47, ranking fourth.

The lack of intermediation with public research centers ranks fifth, with a difficulty score of approximately 2.75. Although the relationship of firms with public research centers exists in multiple forms (partnership agreements, study contracts, etc.), it is not sufficiently developed to enable public research centers to support innovation development and implementation.

The difficulty score rises further to 2.82, when it comes to non-compliance with regulations in terms of competition law and intellectual property rights. The executives of the surveyed firms believe that the authorities (in this case the competition council, an autonomous administrative authority under the Ministry

responsible for Trade) do not fully perform its regulatory role, which is to prevent any restrictive practices of competition and to control economic concentrations. Moreover, intellectual property issues frequently arise in the context of open innovation. Stakeholders, namely the firm on one hand and the research institution on the other, often clash over the patenting of innovations to which both the firm's experts and the researchers have contributed.

Ranking seventh with a score of 2.88, high innovation costs represent a significant difficulty for many firms. Difficulty reaches the critical level of around 3.01 when it comes to government assistance (tax incentives). The surveyed firms state that the government has no effective fiscal policy to encourage industrial operators in electronics to develop innovation. Finally, market uncertainty is considered the most critical obstacle to innovation with a score of around 3.21. This dimension constitutes a significant problem for all surveyed firms due to the uncertainty prevailing in the electronic product market, the lack of information, and, above all, the unfair competition.

Overall, the results show that the main difficulties faced by firms are not only internal but also institutional and reflect weaknesses in the innovation ecosystem. The highest difficulties are related to market uncertainty, limited government support, high innovation costs, and regulatory issues. This suggests that firms operate in an environment where market, institutional, and financial conditions do not sufficiently support innovation. At the ecosystem level, limited access to external funding and the weak effectiveness of government incentives indicate that financial and institutional mechanisms do not adequately support firms throughout the innovation process, from developing ideas to implementing and bringing them to the market. The results also show weak links between firms and public knowledge producers. Although firms have relationships with public universities and research centers through partnership agreements, study contracts, and other forms of collaboration, these relationships remain limited and do not sufficiently support the transfer and use of scientific and technological resources available in universities. The fact that contacts often take place through personal rather than institutional networks also suggests that relationships within the innovation ecosystem remain weakly institutionalized.

4.4 From national innovation system to open innovation and ecosystem perspectives: positioning the Algerian innovation landscape

From an open innovation perspective, the institutional framework does not appear to be the main obstacle to innovation in Algeria. The legal and organizational framework does not lag significantly behind those of several developed countries (Amdaoud, 2017). However, the national innovation system remains at a stage of consolidation, and its scientific and technological performance remains relatively weak. This situation can be explained by the fact that, in Algeria, the establishment of effective collaborative

relationships between universities, research organizations, firms, and support structures remains constrained by administrative and institutional barriers. Networks are therefore still underdeveloped, while links between research and the productive sector remain insufficient, limiting collaboration, collective learning, and knowledge circulation (Amdaoud, 2017).

From an open innovation perspective, Chesbrough (2003) emphasizes that innovation depends on firms' ability to mobilize both internal and external knowledge and to collaborate with different partners. Such openness, however, remains subject to several constraints, including a lack of trust among actors, difficulties in governing collaborative relationships, and issues related to intellectual property. These issues are particularly important in the Algerian electronics sector. In this context, one of the main challenges is to strike a balance between protecting strategic knowledge and sharing it, which is necessary for the development of collaborative innovation. This tension between openness and appropriation is also a central issue in the open innovation literature (Chesbrough et al., 2024). Thus, innovation activities remain largely embedded in a state-led national innovation system rather than in an open, dynamic, and highly interconnected ecosystem. This configuration leads firms to prioritize strategies focused more on adaptation, survival, and continuity than on an open innovation approach based on co-creation and the systematic mobilization of external knowledge.

Beyond the need to address the current shortcomings of the innovation ecosystem, it is also essential to adopt a more inclusive view of innovation in Algeria. This perspective should move beyond traditional interactions between universities, firms, and the state to include a broader range of actors, particularly civil society and end users of innovation. This shift is consistent with recent Quintuple Helix approaches, which view sustainable innovation as resulting from interactions among the academic, economic, governmental, societal, and environmental spheres (Carayannis et al., 2018). Finally, it is important to strengthen the role of universities within the innovation ecosystem. Universities are no longer merely producers of knowledge but also important actors in innovation. Through technology transfer, incubators, university-based start-ups, and research partnerships, they facilitate interactions among researchers, firms, public authorities, and investors, thereby contributing to the development of the ecosystem (Perkmann et al., 2013).

These considerations are particularly relevant to the Algerian electronics industry, where the limited coordination among ecosystem actors affects the conditions under which firms pursue innovation. The case of the Algerian electronics industry contributes to the broader literature on innovation ecosystems in emerging economies. It shows that firms can develop and sustain innovation within a weakly coordinated ecosystem by relying more heavily on their internal resources and capabilities. Our findings suggest that ecosystem weaknesses do not necessarily prevent firms from innovating, but rather shape how they develop and mobilize their innovation strategies.

5. RECOMMENDATIONS AND THEORETICAL IMPLICATIONS FOR STRENGTHENING COLLABORATIVE INNOVATION AND THE ECOSYSTEM

While previous studies highlight external collaboration as an important driver of innovation, especially in developed countries, our findings show that firms in institutionally constrained emerging economies may rely more on internal learning and knowledge development. The findings also show that innovation ecosystems depend not only on the presence of different actors, but also on how effectively they interact. The Algerian electronics industry would benefit from moving from a mainly internally driven innovation model towards a more collaborative ecosystem that is still developing. These findings therefore have both managerial and policy implications. Firms should strengthen their internal capabilities while becoming more open to external sources of knowledge. This requires institutionalizing internal mechanisms that support creativity, learning, and knowledge integration, such as cross-functional innovation teams, structured brainstorming sessions, and continuous improvement units. Moreover, investing in employee skills development and internal knowledge-sharing systems would enhance organizational and process innovations, thereby supporting long-term competitiveness.

At the policy level, the state has a key role to play in facilitating interactions within the innovation ecosystem by ensuring a flexible framework that supports coordination and complementarity among actors. Improving the innovation ecosystem therefore requires stronger governance mechanisms and closer university–industry partnerships. Efforts should also focus on strengthening local innovation networks by encouraging collaboration among firms, suppliers, research institutions, and public actors. In particular, innovation clusters, industrial parks, and sector-specific innovation hubs could serve as platforms for collective learning and resource sharing. The establishment of technology transfer offices, applied research platforms, and collaborative R&D programs could further facilitate knowledge exchange and increase the relevance of academic research to industrial needs. Finally, improving regulatory frameworks related to intellectual property and competition could strengthen trust among stakeholders and promote knowledge sharing. Reducing administrative barriers and strengthening trust among ecosystem participants are also essential to improving knowledge circulation and transforming existing innovation resources into a more dynamic and collaborative ecosystem.

6. CONCLUSION

Algeria represents a context characterized by weak cooperation among the actors within the innovation ecosystem of the electronics industry. The findings show that, in a challenging environment with limited external support and weak collaboration, firms in the Algerian electronics sector rely mainly on their

internal capabilities to sustain innovation. The findings also confirm a major characteristic of the Algerian innovation system, namely the existence of several barriers to collaboration among ecosystem actors, particularly between universities and firms.

This situation can be explained by the difficulties firms face in establishing effective relationships with ecosystem actors. Respondents reported that interactions with ecosystem partners are often sporadic and intermittent, contributing only marginally to innovation processes. In addition, the lack of intermediation with university research laboratories, combined with shortages of qualified personnel, limited internal funding, and insufficient access to external capital, represents major obstacles. Consequently, innovation in Algerian electronics firms remains primarily endogenous, relying on internal capabilities, while institutional intermediation and integration within the national innovation system remain weak.

These findings contribute to the literature on innovation ecosystems in emerging economies by showing that weaknesses in the external ecosystem do not necessarily prevent firms from innovating, but rather shape how innovation is developed and sustained. In the Algerian electronics sector, firms compensate for weak ecosystem linkages by relying more heavily on their internal capabilities and selectively engaging with external partners when these relationships provide clear technological or commercial value. The main challenge is therefore not simply the availability of resources and knowledge, but the limited ability to connect, share, and mobilize them across ecosystem actors.

From this perspective, strengthening collaboration and institutional intermediation is essential to create a more connected and supportive environment for innovation. Policymakers and industry stakeholders should therefore focus on strengthening ecosystem linkages, supporting local partnerships, and providing targeted incentives for collaborative innovation. For Algerian electronics firms, combining stronger internal innovation capabilities with more effective ecosystem interactions will be critical for long-term competitiveness and growth. Future research could further investigate the mechanisms through which local knowledge networks can be strengthened and the policies needed to provide effective financial and technical support for collaborative innovation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors used ChatGPT, an AI language model, to assist with the translation of the text from French to English and to improve clarity, fluency, and linguistic accuracy. After using this tool, the authors critically reviewed, edited, and validated the content and take full responsibility for the accuracy and integrity of the published article.

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