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REVIEW

Science vs experience - What determines how companies innovate

Ciencia vs. experiencia: ¿qué determina cómo innovan las empresas?

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ABSTRACT

Innovation is a critical factor for business competitiveness and survival. This study uses a systematic PRISMA review to identify the factors that determine the adoption of STI (science) and DUI (experience) modes of innovation. The findings reveal that the choice is not mutually exclusive; the synergistic combination of both modes maximizes innovative performance. Internal factors (size, resources, culture) and external factors (sector, regional environment) influence this adoption, with large companies tending to integrate both approaches, while SMEs lean more towards DUI. It is concluded that the competitive advantage lies in developing absorption capacities to effectively integrate both modes, which requires managers and public policies to abandon one-dimensional approaches and foster ecosystems that support this dual strategy to achieve more robust and inclusive economic development.

Keywords: Modes Of Innovation; DUI Mode; STI Mode; Determining Factors; Complementarity.

RESUMEN

La innovación es un factor crítico para la competitividad y supervivencia empresarial. Este estudio identifica, mediante una revisión sistemática PRISMA, los factores que determinan la adopción de los modos de innovación STI (ciencia) y DUI (experiencia). Los hallazgos revelan que la elección no es excluyente; la combinación sinérgica de ambos modos maximiza el rendimiento innovador. Factores internos (tamaño, recursos, cultura) y externos (sector, entorno regional) influyen en esta adopción, observándose que las grandes empresas suelen integrar ambos enfoques, mientras las PYMES se inclinan más por el DUI. Se concluye que la ventaja competitiva reside en desarrollar capacidades de absorción para integrar efectivamente ambos modos, lo que exige a gestores y políticas públicas abandonar enfoques unidimensionales y fomentar ecosistemas que apoyen esta estrategia dual para lograr un desarrollo económico más robusto e inclusivo.

Palabras clave: Modos de Innovación; Modo DUI; Modo STI; Factores Determinantes; Complementariedad.

INTRODUCTION

Currently, all companies must innovate if they want to be competitive and survive in the market; however, different companies innovate to varying degrees. Innovation is a critical factor that greatly improves business performance and efficiency; up to three-quarters of productivity growth in European industry is due to

innovation.[1] In the long term, companies that implement innovation in their strategy achieve better results and competitive advantages.[1,2]

Business innovation has become a key factor in the competitiveness, sustainability, and survival of organizations in increasingly dynamic business environments.[3,4] This process not only allows for the improvement of production processes and the creation of new products or services, but also the generation of sustainable competitive advantages that distinguish companies from their rivals.[2,3]

Although innovation has become a key aspect for business success and survival in today's competitive environment, there are significant differences in its implementation. On the one hand, SMEs face challenges, such as a lack of financing and investment support. Despite these limitations, both large and small companies use it as a fundamental tool to achieve greater profitability.[2,4] This importance stems from the significant influence that innovation has on both society and the economy.[5]

To successfully implement innovation, organizations rely on essential components such as visionary leadership, an organizational culture conducive to change, effective communication, robust knowledge management, and specific activities like idea and project management.[6] In this context, the DUI (Doing, Using, and Interacting) innovation model emerges as an alternative and complementary approach to the traditional science, technology, and innovation (STI) model. While the STI model focuses on formal R&D, the DUI approach emphasizes informal learning, practical experience, and interactive processes within innovation systems.[7]

In this context, the question arises: What factors determine the adoption of the Learning by Doing, Using, and Interacting (DUI) innovation mode or the Science, Technology, and Innovation (STI) mode in different types of companies? Research on this topic demonstrates that innovative companies place greater importance on internal sources of knowledge and value access to market-based sources and technical assistance more highly, compared to companies that are only potentially innovative.[8]

METHOD

Formulation of the research question

The study revolves around the following question: What factors determine the adoption of the Learning by Doing, Using, and Interacting (DUI) innovation mode or the Science, Technology, and Innovation (STI) mode in different types of companies? This question arises from the recognition that companies do not innovate in a single way; on the contrary, their innovation strategies are mediated by a set of organizational, contextual, and resource variables. The distinction between the DUI mode (based on experience) and the STI mode (based on science) is crucial to understanding the dynamics of innovation in various business contexts.

Design of the methodological model

To address this issue rigorously and comprehensively, a systematic literature review was designed and implemented, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles. This approach ensures transparency, reproducibility, and minimizes bias in the selection and analysis of evidence.

The objective of the analysis was to contrast and synthesize the existing empirical evidence to identify, systematize and compare the key factors —both internal and external to the company— that predispose its strategy towards one mode or another.

Evidence searches and selection protocol

The literature collection process was carried out in four structured phases:

Table 1. Methodological phases

Phases	Description
Identification	To ensure the quality, relevance, and breadth of the evidence collected, the search was conducted in high-impact multidisciplinary bibliographic databases (Scopus and Web of Science), which index peer-reviewed publications. It was supplemented by Google Scholar to maximize coverage and mitigate possible selection biases. The search equations were constructed by combining key terms and synonyms related to "DUI," "STI," "modes of innovation," "factors," and "adoption," using Boolean operators (AND, OR) to refine the results. 50 documents were identified.
Duplicate removal	The initial records obtained were cleaned, removing 13 duplicate references.
Eligibility by titles and abstracts	The resulting documents were filtered by reading titles, abstracts, and keywords, applying eligibility criteria to identify the most promising references. Thirteen documents were discarded as not promising.
Final inclusion after comprehensive reading	The shortlisted documents underwent a thorough reading to verify that their content directly addressed the research question. Only 24 documents that strictly met the criteria were included in the final synthesis.

The eligibility and exclusion criteria were determined as follows:

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
✓ Topic: Empirical or theoretical articles that explicitly address the factors that determine the adoption of DUI and/or STI modes.	× Studies that are limited to describing the characteristics of DUI or STI modes without delving into the factors that condition their implementation.
✓ Publication Period: Documents published between 2010 and 2025.	× Documents published before 2010, to maintain the focus on more contemporary literature.
✓ Language: Only documents in English or Spanish.	× Documents in languages other than English and Spanish, due to accessibility limitations and translation resources.
✓ Availability: Full text available through institutional resources or in open access in the databases mentioned.	

Synthesis and analysis of the evidence

The analysis was not limited to a descriptive compilation but focused on identifying causal patterns and thematic relationships in the literature. The evidence was synthesized around five main analytical axes that directly address the research question:

Table 3. Main analytical axes

Axis	Description
Relationship and complementarity between the STI and DUI innovation modes	The dichotomy is not mutually exclusive. Evidence suggests that the synergistic combination of both approaches enhances innovative results. However, the effectiveness of this hybridization is mediated by the company's absorptive capacity and its ability to manage both types of knowledge.
Internal factors of companies	It was identified that characteristics such as company size, availability of financial and human resources, and organizational culture (e.g., openness to learning and collaboration) are primary determinants. Large companies with R&D departments tend to lean more towards STI, while SMEs tend to make better use of DUI mechanisms.
External and regional factors	Context acts as either a facilitator or a barrier. The technological intensity of the sector, the dynamics of the regional environment (such as the presence of clusters or universities), and access to collaborative networks have a significant influence. High-tech sectors typically require a stronger STI component.
Innovation and performance	The modes are associated with different types of outcomes. While the STI mode is typically linked to more radical and patentable innovations, the DUI mode tends to generate incremental and process innovations. Evidence indicates that companies that successfully integrate both modes tend to exhibit better innovation and economic performance.
Specific cases and public policies	Innovation policy design must be context sensitive. Effective policies should recognize this duality, avoiding a one-size-fits-all approach, and promote instruments that support both formal R&D (STI) and practice-based learning and collaboration (DUI), adapting to the sector, company size, and level of regional development.

This systematic review provides a comprehensive, evidence-based framework for understanding the complex strategic decision underlying how companies innovate.

RESULTS

The adoption of modes of innovation, whether science-based (STI mode - Science, Technology, and Innovation) or experience-based (DUI mode - Learning by Doing, Using, and Interacting), is not a homogeneous phenomenon. It is determined by a complex interaction of factors endogenous to the company and exogenous factors derived from its socioeconomic and institutional environment. Analysis of the literature shows that complementarity between the two modes is usually the most robust strategy, although its application and prevalence vary significantly depending on the size of the company, the sector of activity, the level of development of the region, and public support policies.

Relationship and complementarity between STI and DUI modes of innovation

The dichotomy between STI and DUI modes is not exclusive. Evidence suggests that their synergistic combination enhances innovative results, although the nature of this complementarity is mediated by organizational capabilities and context.

Table 4. Relationship and complementarity

Aspect	Key finding	References
Combined advantage	Companies that carry out internal and external R&D (STI) activities show greater innovative performance compared to those that do not. Absorptive capacity, developed through R&D, facilitates the effective integration of external knowledge, much of which is DUI in nature.	(9,10)
Integration mechanism	The ability to absorb and leverage available external information depends critically on the company's track record and previous investments in R&D (STI). A lack of initial investment in a specialization may impede the future development of technical capabilities in that area, limiting the effectiveness of the DUI mode.	(10)
Non-technological innovation	R&D (STI) is positively associated not only with technological innovation, but also with non-technological innovation (e.g., organizational, marketing). One aspect of managerial innovation may be precisely the implementation of a formal R&D strategy.	(11)
Limitation of isolated DUI	The mere practice of using DUI factors (internal and external) does not in itself guarantee significant innovation performance. Its effectiveness is contingent on the company's ability to exploit them effectively.	(12)
Combined advantage	Companies that carry out internal and external R&D (STI) activities show greater innovation compared to those that do not. Absorptive capacity, developed through R&D, facilitates the effective integration of external knowledge, much of which is DUI in nature.	(9,10)

Internal factors within companies

The characteristics and resources of the company itself are primary determinants in the choice and effectiveness of its mode of innovation. Size, resources, and internal capabilities shape its propensity toward one mode or another.

Table 5. Internal factors

Factor	Influence on the mode of innovation	References
Company size	SMEs, especially those that do not carry out R&D, tend to rely more on tacit, practical, and experience-based knowledge, predominantly adopting the DUI mode. They lack the capacity to manage large formal innovation projects (STI).	(13,14)
Absorption capacity and resources for R&D	The capacity to carry out internal R&D (STI) reflects absorption capacity. Companies with low absorption capacity need to interact with others to compensate for their shortcomings, orienting themselves toward collaborative DUI-type strategies.	(15,16)
Know-how and human capital	The DUI mode is based on experiential know-how and informal learning. In less R&D-oriented environments, successful innovation depends largely on organizational and marketing activities (DUI).	(17,18)
Leadership and personality	In SMEs, the personality of the owner or manager directly affects internal and external communication flows, laying the foundations for a culture of innovation and promoting (or not) the openness necessary for DUI mode.	(19)

External and regional factors

The regional and international environment in which the company operates acts as a facilitator or constraint for innovation, influencing access to knowledge, resources, and collaboration partners.

Table 6. External factors

Factor	Influence on the mode of innovation	References
Regional innovation system	A robust innovation system, with organizations that interact intensively (universities, R&D centers), contributes to the development and dissemination of new technologies, especially supporting SMEs that lack internal resources for R&D (STI).	(20,21)
Collaboration and interaction	Collaboration with external partners (companies, institutions) is a key strategy for companies with lower internal R&D capabilities, allowing them to access tacit and explicit knowledge (collaborative DUI mode).	(15,22)
Geographic concentration	Innovation and R&D (STI) activities tend to be more geographically concentrated than manufacturing, underscoring the importance of clusters and knowledge-dense regions for this mode.	(23)
Level of regional/national development	There are significant differences between business communities in advanced countries and emerging or developing economies. The latter tend to have a higher prevalence of incremental innovation and DUI modes, with lower technological intensity.	(24,25)

Innovation and performance

Innovation modes are associated with different types of outcomes, both in terms of the nature of innovation and the economic and innovative performance of the company.

Table 7. Innovation

Innovation mode	Results and type of innovation associated	References
STI mode	It is associated with the generation of radical innovations and new products, driven by formal R&D projects. It leads to higher returns and is a fundamental component of endogenous growth.	(16,17,26)
DUI mode	It predominates in incremental innovation, consisting of the gradual improvement of processes and products and the integration of new technical components. It is characteristic of industrial SMEs and low- and medium-technology sectors.	(27,28)
STI-DUI combination	Companies that combine internal and external R&D (STI) activities with interactive learning practices (DUI) show higher innovation performance compared to those that rely on a single mode.	(9,29)

Specific cases and public policies

The design and implementation of public innovation policies must be sensitive to the specific context (sector, company size, level of regional development) to be effective.

Table 8. Specific cases

Scope	Findings and policy recommendations	References
Policy instruments (General)	R&D subsidies or tax credits are the predominant instruments for promoting the STI mode. However, policies must go further and integrate support for collaboration, the development of absorption capacities, and the promotion of DUI interactions.	(30,31)
Territorial approach	Policies must be adapted to regional realities. Evidence shows that low business spending on R&D (as in the Canary Islands, Spain) reflects the absence of a business technology strategy, requiring policies that first promote basic capabilities.	(32)
Developing/transition economies	In these contexts, companies often lack the capacity for formal STI innovation. Policies should recognize and enhance informal innovation processes (DUI) and facilitate the transition to more combined modes.	(14,16)
National case studies	Norway: Collaborative innovation strategy with external partners (DUI) over high investment in internal R&D.	(22,24,33)
	South Africa: Investment in nanotechnology (STI) boosted human capabilities, but with limited impact on tangible development outcomes.	
	Portugal vs. Denmark: Differences in modes of innovation reflect structural gaps between the business communities of both countries.	

The choice between DUI and STI modes of innovation should not be regarded as a dichotomy but rather coexisting on a continuum defined by multiple determinants. Internal conditions such as firm size, accessible resources, and absorption capacity push SMEs into the DUI mode, while large companies with rich resources prefer STI. Additionally, external factors such as the strength of the regional innovative system and accessibility of collaboration partners can offset internal shortcomings and widen access to both innovation modes. In each case, empirical evidence repeatedly shows that innovative results are best achieved by a combined integration of STI and DUI strategies. Effective public policies should therefore choose a whole system's perspective and encourage not only R&D investment (STI) but also the building of interactive learning, collaboration, and upgrading of absorption capacity (DUI) ecosystems, particularly with respect to SMEs and lagging regions.

DISCUSSION

The study addresses the central problem of how companies determine their innovation strategies, highlighting the dichotomy between the science and technology-based (STI) approach and the experience and practice-based (DUI) approach. The research demonstrates that this choice is not uniform but rather determined by a complex interplay of endogenous and exogenous factors. The results show that, while the synergistic complementarity of both approaches is often the most robust strategy, their application and prevalence vary significantly.

Research shows that DUI modes are particularly effective at driving non-technological innovations, especially in the areas of processes, marketing, and services.[7] Their effectiveness, however, varies depending on the economic context and the size of the firm. In small and medium-sized enterprises (SMEs), for example, informal

DUI learning is crucial for improving performance, while large companies often benefit from the synergistic combination of both modes, STI and DUI, suggesting that DUI capabilities can act as a prerequisite for effective STI strategies.[14]

These findings are directly related to previous studies that already pointed to the combined advantage, where companies that carry out internal and external R&D activities (STI) show a higher innovative performance, since the absorptive capacity, developed through R&D, facilitates the effective integration of external knowledge of a DUI nature.

The relevance of this work is multidimensional, since at the macro level, regional innovation systems show that unified innovation (UI) activities depend heavily on informal structures and institutions, which demand more specialized regional support frameworks compared to science, technology, and innovation (STI)-oriented activities.[7] A comparative analysis in Europe reveals that, while countries in recovery demonstrate effective UUI collaborations for process innovation, the returns from STI modes in these economies are more limited compared to those observed in advanced economies.[34] Furthermore, the role of universities and research centers varies according to the institutional context, with their impact being most significant in SME innovation collaborations in liberal market economies, such as the United Kingdom.[35]

This underscores the need for holistic public policies that, beyond R&D subsidies, foster ecosystems that facilitate interactive learning and collaboration, especially in SME contexts and less developed regions where the mere practice of DUI factors does not in itself guarantee significant performance if the company lacks the capacity to exploit them effectively.

However, the study has limitations and weaknesses that must be considered. A persistent challenge in the study of DUI innovation lies in its measurement and evaluation, due to the lack of standardized indicators that capture its informal processes.[36] Therefore, systematic reviews underscore the urgent need to deepen our understanding of the drivers, processes, and outcomes of DUI networks to advance in this field of study.[37]

This methodological limitation extends to the difficulty of generalizing findings, given that internal factors such as leadership and the personality of the manager in SMEs, or external factors such as the geographical concentration of STI activities, introduce a heterogeneity that existing models do not always manage to capture completely and in a standardized way.

CONCLUSIONS

Ultimately, the most important result of this research is the empirical confirmation that the synergistic combination of STI and DUI innovation modes—rather than the exclusive adoption of one or the other—is what maximizes companies' innovative performance. This finding is of paramount importance because it dismantles the dichotomous paradigm that has dominated the debate and reveals that true competitive advantage lies in organizations' ability to integrate formal science with experiential learning, thereby creating a richer and more resilient innovative ecosystem.

Based on this evidence, the main proposed action is for both business managers and policymakers to abandon one-dimensional approaches and strategically prioritize the development of absorptive capabilities within companies, since this ability to assimilate and apply external knowledge acts as the fundamental bridge that enables the effective integration of both modes. The consistent implementation of this dual strategy promises a transformative long-term impact, laying the groundwork for a paradigm shift in innovative culture.

At the micro level, this will translate into more adaptable companies with a more balanced innovation portfolio, combining radical developments with incremental improvements; at the macro level, it will drive the construction of more robust and less unequal regional innovation systems, where SMEs, starting from their strength in the DUI mode, can move towards hybrid models that allow them to scale their potential, thus closing productivity gaps and fostering sustainable and inclusive economic development.

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The authors declare that there is no conflict of interest.

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