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Artículo Científico

A service science framework to improve innovation in manufacturing. Comparative case study of food and non-edible agriculture industries

Un marco de ciencia de servicios para mejorar la innovación en la manufactura. Estudio de caso comparativo de las industrias alimentaria y agrícola no comestible

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ABSTRACT

This article describes a knowledge intensive business services (KIBS) approach to improve innovation processes with a case study applied to two industries: food processing and production of non-edible agricultural products. The case study shows a method with its different stages for supply chain identification in the two selected industries and describes its use for identifying innovation projects. Based on a literature review on processes and innovation, a framework for improving innovation processes is proposed. The main contributions of this article consist in proposing a framework to support the decision of new innovation projects in manufacturing companies, exposing lessons that can be useful for managers who want to boost innovation in their manufacturing companies. This framework includes both strategic and operational dimensions to identify some of the key challenges and opportunities in innovation projects.

Keywords: SIPOC; Resource Management; Systemic Innovation.

RESUMEN

Este artículo describe un enfoque basado en los servicios empresariales intensivos en conocimiento para mejorar los procesos de innovación mediante un estudio de caso aplicado a dos industrias: procesamiento de alimentos y producción de productos agrícolas no comestibles. El estudio de caso muestra un método con sus diferentes etapas para la identificación de la cadena de suministro en las dos industrias seleccionadas y describe su uso para identificar proyectos de innovación. Con base en una revisión bibliográfica sobre procesos e innovación, se propone un marco para mejorar los procesos de innovación. Las principales contribuciones de este artículo consisten en proponer un marco para respaldar la toma de decisiones sobre nuevos proyectos de innovación en empresas manufactureras, exponiendo lecciones que pueden ser útiles para los gerentes que desean impulsar la innovación en sus empresas manufactureras. Este marco incluye dimensiones estratégicas y operativas para identificar algunos de los desafíos y oportunidades clave en los proyectos de innovación.

Palabras clave: SIPOC; Gestión de Recursos; Innovación Sistémica.

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1. INTRODUCTION

Today, the globalization of business requires clear perspectives on the quality levels and scalability possibilities that will ensure sustainable growth for companies while meeting market objectives. The traditional manufacturing sector faces the same challenges every day. Industries that develop and manufacture products have to permanently improve their processes through optimization, to make them more efficient, competitive, profitable and customer-focused, leaving the traditional prioritization of the analysis of their resources, limitations, disadvantages and weaknesses in the background, and focusing on the implementation and deployment of innovations.

Innovation projects must involve actors from various organizations collaborating to identify the right way to design and implement innovations.

In this context, the interdisciplinary and intercultural approach to innovation development can be found in the analysis of technological competencies that determine that innovation can be achieved on the basis of specific knowledge that when combined favor the integration of knowledge and the development of scientific management management (Arcos & Padilla, 2023; Arcos Proaño, 2018; Morcillo, 2007).

This involves collaboration, which is a way to save costs and avoid duplication of effort. It may be that one party is better at A while the other is better at B, and they can exchange skills; even if one party is better at A and the other has no better B to offer, it may still make sense to share A at the right price (Brandenburger & Nalebuff, 2021).

Service science aims to develop knowledge-based methods with tools, methods and practical implications for industries. As the era of the knowledge economy emerges, the importance of knowledge management performance gradually increases (Mu-Yen et al., 2009).

Methodologies such as those proposed by Ahn et al. (2006), explain that the commercial performance of a new product in the market can be considered as the result of the activity of exploiting new products, while knowledge performance, the degree of creation of new knowledge, can be seen as the result of the exploratory activity of new product development. This points to the importance of organizational ambidexterity in terms of exploration and exploitation prior to offering enhancement and diversification.

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As companies attempt to restructure their offerings, interdisciplinary approaches are required to understand how they should be designed, delivered and support diversification.

In this context, it is also accepted that a project is a temporary endeavor undertaken to create a product or service, and that it requires business analysis of: opportunity, project team, creation of unique products (i. A product or item produced, which is quantifiable, and may be a finished item or component; ii. The ability to provide a service, such as business functions that support production or distribution; iii. An outcome, such as outputs or documents that provide knowledge that can be used to determine whether or not a trend exists or whether a new process will benefit society) (Project Management Institute, 2004).

This article seeks to combine these strategic, methodological, administrative and scientific notions to define a service science framework to improve innovation processes in manufacturing companies. This involves considering the value creation approach that is based on the evaluation of possible innovation initiatives with a comprehensive view of the activities carried out within companies.

In this regard, there is a simple principle in the value creation approach: companies that achieve lasting financial success create substantial value for their customers, their employees and their suppliers (Oberholzer-Gee, 2021). Value creation has been analyzed through the concepts of production processes, technology and innovation, among others, by distinguished authors such as Schumpeter (Schumpeter, 1934) and Porter (Porter, 1985), from which it can be deduced that economic systems are driven by new products and services, new production, marketing and logistics methods, new markets and new forms of industrial organization. The value chain framework is also established to understand the implications of different activities carried out by companies.

This theoretical framework considers the conditions that allow companies to facilitate collaborative exchange between their internal actors and external actors to create value. In this regard, four main value drivers can be raised, coming from the analysis of contact networks that are good indicators of collaboration metrics (Parung & Bititci, 2008), and coming from the theory of technological competencies (Giget, 1998; Morcillo, 1997; Cañibano et al., 2002; Arcos Proaño, 2017; Arcos & Padilla, 2023), strategic organizational assets: 1.1 physical (industrial

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capacity and tools); 1.2 financial assets (money invested in project development, including market research and prototypes); 2. human capital (tacit and expressed knowledge, skills, experience, education, competencies, productivity, commitment); 3. structural capital (brand, databases, licenses, product path, culture, scientific and technological mastery); 4. relational capital (market performance, value chain performance, performance with other stakeholders). Therefore, a strategic proposal of this style seeks greater creation of organizational value that translates into better or new long-term business performance by organizing and structuring the interaction that must exist between suppliers (S), productive inputs (I), processes and procedures (P), products and other outputs within the process (O), and internal and external customers (C). The case studies analyzed for this research are based on the development and implementation of the production chain by considering the five elements mentioned (SIPOC), which allows identifying key macro processes and subprocesses to describe the management method and determine how and where to promote innovation and development (Arcos & Carrera, 2023). Consequently, in this paper a new organizational modeling approach is proposed, which incorporates the analysis of stakeholders and helps to identify the complexity of the interaction of the parties in the production chain considering a macro level of process and the indispensable assets to be able to innovate. The model presents a new mapping technique that describes the elements Supplier, Inputs, Process, Outputs and Customer, combined with the Unified Resource Management Model for Systemic Innovation (URMMSI – GURIS for its original acronym in Sapnish) (Arcos Proaño, 2018; Arcos & Padilla, 2023), thus achieving a mixture of the traditional SIPOC method with a Value Creation Map by considering the elements of the URMMSI for managing innovation based on knowledge, thus accomplishing solidity to rationalize a process with a comprehensive end-to-end vision to visualize indicators, opportunities for improvement, and innovation opportunities.

1.1. SIPOC model

Companies must combine a set of productive factors and technologies, both tangible and intangible, from which they can produce and develop organizational competitiveness, promote adequate management of knowledge and organizational capabilities, to learn and innovate in the context of the different links that make up their production chain.

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The SIPOC model (suppliers, inputs, processes, outputs, customers) consists of a methodology to outline a production chain with the possibility of identifying the global vision of an industry (at a macro or micro level), and facilitate control processes for management improvement (Arcos Proaño, 2019). In this regard, Marques & Requeijo (2009) point out that SIPOC diagrams are a powerful tool to map processes at a high level or to map a process in increasing levels of detail, that is, macroprocesses, processes and subprocesses.

The application of the SIPOC model includes a five-column diagram (Arcos Proaño, 2019; Arcos et al., 2006).

- The first column, "supplier," represents the various actors in the production chain and/or the owner of the macroprocess.
- The second column describes the main "inputs" generated and delivered by suppliers.
- The third column, "process", describes in a sequential, vertical and descending manner the macroprocesses considered in an analysis. The description of the process attempts to clarify how the final customer can be reached as a result of the manufacture of the product.
- The fourth column, "outputs", represents the results obtained from the execution of each macroprocess. This analysis is important to know at what point in the production process the marketable products are reached, and which are the main suppliers and inputs.
- The fifth column, "customer", describes the internal and/or external customer who receives the outputs described in each case.

Various studies in the field of productive improvement in industries have applied the SIPOC model to address areas such as: sustainable manufacturing (Vinodh et al., 2016), production systems design (Matt, 2014), review and improvement of a supplier performance monitoring and improvement process (Parkash & Kaushik, 2011), telecommunications network planning framework (Todd & Doucette, 2013), characterization and proposal for the improvement of intellectual property management in the floriculture sector of Ecuador (Arcos & Carrera, 2023), hybrid framework to improve the supply chain management process from the integration of SIPOC and definition-measurement-analysis-improvement-control tools (Mishra & Kumar Sharma, 2014), method for the design of a digital platform focused on the management of improvements in the productive sector of Ecuador (Arcos Proaño, 2019), identification of

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the elements of the SIPOC model, for the implementation of continuous improvement and performance control mechanisms (Sabir et al., 2015).

This paper presents the application of the SIPOC diagram in the two proposed industries, according to the literature and case review described.

1.2. Unified Resource Management Model for Systemic Innovation (URMMSI)

The URMMSI is based on the organizational learning theory that states that knowledge leads to the correct management of resources and capabilities, which consists of at least two primary fields in companies: i. strategic management; ii. intangible assets (Arcos & Padilla, 2023; Arcos Proaño, 2018; Arcos Proaño, 2017; Itami & Roehl, 1987; Nelson, 1991; Grant, 1991; Ansoff, 1965; Grant, 1995).

Both strategic management and intangible assets are complementary components and have elements in common (Arcos & Carrera, 2023). Therefore, it is not easy to separate them in the analysis, however, it can be noted that strategic management is the investment that organizations can make seeking that competitors cannot match it; the objective in this case is to generate greater demand and/or achieve lower costs, the first seeks customer captivity that can arise from the habits that customers develop, search costs or switching costs. The second is related to the cost advantages that are produced by the incidence of technology or by a larger scale of operation (Greenwald & Kahn, 2005).

Then again, intangible assets are non-routine investments in marketing, training, software, current R&D expenses and current innovation expenses. They include all non-capital investments made for the development of the company, whose potential benefits materialize in a period of time that exceeds the year in which they are incurred. The fact is that knowledge-intensive solutions, make it possible to enhance the organization's resource and capacity management and favor productivity, efficiency, control, quality of the final product and competitive access to markets, mainly.

Thus, learning makes the organization stronger and acquires a great capacity to respond to market externalities, improving its capacity to manage resources, as well as to create, absorb, retain, use and disseminate economically useful knowledge. The organizational learning process strengthens the management of resources and capabilities, and allows the company to

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accumulate and master certain competencies as determining factors that generate innovation. As in a waterfall, the force, speed and acceleration of the fall of water are increasingly greater, depending on the volume of water and the height of the fall, just as in the innovation process that depends on the amount of knowledge generated, accumulated and absorbed, and the standard established by senior management in reference to the level required in the most important development factor, the human one (Arcos Proaño, 2018).

Therefore, URMMSI allows companies to think and plan in a contemporary business environment that has high levels of competitiveness. By combining URMMSI with SIPOC, it is possible to diagram a scheme that describes the elements of the production chain from the point of view of customer focus and highlighting the knowledge requirements for each link.

By identifying its competencies, the entire organization knows how to design its competitive advantage and can allocate resources to build technological and production links to serve its market (Prahalad & Hamel, 1990). Therefore, URMMSI allows key performance indicators (KPI) to be established, spaces for improvement to be identified, and lines of research to develop innovations.

2. MATERIALS AND METHODS

2.1. Case study research

For the development of the case study research method, the SIPOC diagrams of two different manufacturing companies were used, one is a company dedicated to the production and processing of non-edible agricultural products and the other is a meat production and processing industry.

In order to maintain the confidentiality of the two organizations, their names, locations and description of the macroprocess (considered an industrial secret) are omitted. A new SIPOC diagram is established below, but this time combined with the URMMSI (see Figure 1).

Figure 1 shows the result of the combination of the two models (SIPOC + URMMSI), which constitutes the service science framework for improving innovation processes in manufacturing companies. This framework highlights the areas of the two companies analyzed, in which innovation project proposals were made.

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Figure 1. Framework of the combined SIPOC and URMMSI models.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Suppliers	Inputs			Process			Outputs		Customers				
2	*(Providers of the required resources)*	*(Resources required by the process)*			*(Top level description of the activity)*			*(Deliverables from the process)*		*(Anyone who receives a deliverable from the process)*				
3	6º Who is the supplier of each input?	5º What inputs are required to allow the action to be executed?	7º Cost	8º What is the importance of the input in the process?	10º What does the process/action owner expect from each input?	9º Owner of the process/action	1º What is the process (describe each action to execute)	2º What are the results of the action described?	11º Follow up (what is the improved version of the result obtained)	4º What does each client expect from each result?	3º Who is the client of each result?		Alternatives for continuous improvement	Lines of research to develop innovations
4												KPI		
5														

Source: Direct investigation.

In the proposed framework, the traditional five columns of a SIPOC diagram become eleven columns, to which three additional columns are attached to describe the KPIs, alternatives for continuous improvement, and lines of research to develop innovations.

The disaggregation of the five columns of the SIPOC model incorporates the necessary space for the description of eleven columns in total (A-K) (see Figure 1), in which it is possible to establish, horizontally, to the right and to the left of the central column "1º What is the process", everything that each action of the established macroprocess requires. The macroprocess is the first thing that must be described in the diagram, considering the sequentiality of the actions, so that these are presented from top to bottom in each of the cells of the green column (column G). Once all the actions of the Macroprocess have been established, the team in charge of designing the framework must follow the order of the numbers that are established in each statement located to the right and left of the first statement "1º What is the process" (row 3). That is, the construction of the framework, after having the establishment of the macroprocess ready (in column K), is horizontal, following the reference order of each statement (in row 3).

It is essential that the detail for the collection of the information that is registered in the framework be very detailed and at the same time synthesized.

Once the description of the green column (column G) has been completed, and the details of the rest of the columns whose statements are in row 3, an aggregate analysis is carried out according to the colors established in row 4, as follows:

- From the analysis of the contents that appear under columns E, H, J, which have the yellow badge, the KPIs are established, in column L, from top to bottom.

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- From the analysis of the contents that appear under columns A, C, D, F, G, K, which have the purple badge, the alternatives for continuous improvement are established, in column M, from top to bottom.
- From the analysis of the contents that appear under columns B, I, which have the orange badge, the lines of research to develop innovations are established, in column N, from top to bottom.

Therefore, the application of a framework that combines the SIPOC and URMMSI models for improving innovation processes in manufacturing companies constitutes an innovation tool in the category of service science. The framework promotes the knowledge of the company and allows the detection of opportunities to enhance the mastery of technological skills that are determinants of innovation (Arcos & Padilla, 2023).

In this sense, it is understood that the proposed framework acts as a catalyst for innovation, so the question for this research is: how to improve the innovation process by using the model that combines SIPOC and URMMSI?

3. RESULTS

Once the analysis of the traditional SIPOC scheme of the two industries considered in the case study was carried out, this information was applied to the Framework of the combined SIPOC and URMMSI models. For each case, columns L, M, N were reviewed, and the corresponding contents were established.

Figure 2 shows, in light blue, the information of one of the actions of the food processing and production company, and in pink, the information of one of the actions of the non-food agricultural products processing and production company.

The fact is that only these two groups of information from each industry were selected, to highlight the identification of the most important process (according to column G), and all the details of the statements of each element of the SIPOC (according to the statements in row 3), and KPIs, Alternatives for continuous improvement, Lines of research to develop innovations were proposed (see Figure 2).

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Figure 2. Framework of the combined SIPOC and URMMSI models including two industries analyzed.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Suppliers	Inputs			Process			Outputs		Customers				
2	*(Providers of the required resources)*	*(Resources required by the process)*			*(Top level description of the activity)*			*(Deliverables from the process)*		*(Anyone who receives a deliverable from the process)*				
3	6º Who is the supplier of each input?	5º What inputs are required to allow the action to be executed?	7º Cost	8º What is the importance of the input in the process?	10º What does the process/action owner expect from each input?	9º Owner of the process/action	1º What is the process (describe each action to execute)	2º What are the results of the action described?	11º Follow up (what is the improved version of the result obtained)	4º What does each client expect from each result?	3º Who is the client of each result?			
4												KPI	Alternatives for continuous improvement	Lines of research to develop innovations
5	Purchasing department. Production department workers.	Raw materials (according to recipe)	*CONFIDENTIAL*	High	Compliance with raw material and equipment safety processes	Sub Production Management	6. Production of products according to catalogue	Raw materials ready for mixing according to recipe	New products for a new market with higher demands for quality in flavour and presentation	Raw materials in optimal conditions	Head of Production	recipe values = values received for preparation	Checklist from a technical sheet	Implementation of new machinery for product diversification
6	Importer, producer	Tools, fertilizers, fungicides	*CONFIDENTIAL*	High	Stock in warehouse for use	Head of cultivation	8. Development of cultural activities	Crop management	Data-driven crop management	Increased productivity	Agricultural Technical Chief	Productivity = 1	Implementation of a cultural activities checklist for digitalized control	Implementation of a sensor network to improve crop management based on real-time weather data

Source: Direct investigation.

4. DISCUSSION

The use of the Framework of the combined SIPOC and URMMSI models helps to obtain business information to map the reality of the operations and the strategy of the organization. This framework allows a company to be able to make decisions in search of the establishment of indicators, continuous improvement, and what is capable of innovation.

In the case of the food processing and production company, the need for the implementation of new machinery for product diversification was established, and an investment project was carried out for the acquisition of the new technology, demonstrating a positive ROI. Until the publication of this paper, the company's Management was in the process of analyzing the investment project.

In the case of the company for the processing and production of non-food agricultural products, the need for the implementation of a sensor network to improve crop management based on real-time weather data was established, and an investment project was carried out for the acquisition of the new technology, demonstrating a positive ROI. The project was successfully implemented and the impact on cost reduction is notable, as well as the productivity achieved after the implementation of the new technology.

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Therefore, the research question is answered favorably, in the sense that the framework that combines the SIPOC and URMMSI models does help to improve the innovation process in companies, and constitutes an innovation tool for decision-making, which also helps to establish KPIs and Alternatives for continuous improvement.

5. CONCLUSIONS

In both case studies, it was shown that the high-level description of the macro process favors the establishment of the detail of activities that allow the execution of each action of the process. This information is useful to establish a battery of KPI that allows management to know when preventive and even corrective actions should be carried out due to the knowledge of the expected results in the company's operations.

This paper demonstrates the importance of the proposed framework to establish continuous improvement alternatives, since it shows a comprehensive mapping of the company's operations and strategies, from which proposals can be designed to manage the quality of the industry.

Likewise, the detail of the information, and the technical-practical exercise of use and control of operations and strategies through the application of the framework, allows for the development of Lines of research to develop innovations, which improves the direction of companies whose focus is growth and competitiveness by taking advantage of innovation.

The possibility of deepening the current study and developing a digitalized system of the proposed framework remains open.

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