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Original Article

Characterization, Analysis and Strategies for the Optimization of the Supply Chain of the Pisco Production Sector

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Abstract - The chain stands as a central element for business management, and in the pisco sector, this system involves grape cultivation, pisco production, distribution, and final consumer sales. In this arrangement, the direct interactions between grape producers and the manufacturers, distributors, and end consumers are an observable matter. This academic effort aimed at the identification of the variables that influence the supply chain efficiency and its performance. Furthermore, it sought to define actions for the improvement of the situation. This work used qualitative and non-experimental case study methodology, which was supported by engineering tools. The resulting findings show that the quality of the grape, the capacity for production, the logistics flow, and the demand of the market are the main drivers of outcomes. Another point concerns cost analysis, where there was a revelation of a 33 percent overrun. This means that production costs reached the level of 20 soles for each liter compared to the earlier target, which was 15 soles. The utilization of Value Stream Mapping, PESTEL, and MACTOR tools enabled the development of a structured framework. This framework was validated by industry experts on this matter, and it enables the ability to reduce costs, improve the quality consistency, and strengthen export performance. The successful implementation of these actions will make a contribution to greater competitiveness in the pisco sector and will support national economic growth.

Keywords *- Cost reduction, Engineering tools, Pisco, Sector plan, Supply Chain.*

1. Introduction

Peru has global recognition as the leading producer and exporter of pisco. This serves as a symbol of the national spirit, contributing about fifteen percent to the total exports of the country. With an annual contribution of over 8.6 million USD, pisco is distributed to over forty international markets. Apart from its social and economic importance, the industry is faced with inefficiencies in the entire supply chain. One of the most outstanding inefficiencies is the production cost of 20 soles per liter, which is thirty-three percent higher than the industry standard of 15 soles. The high production cost is a result of a number of factors, mainly the fragmented nature of logistics, the quality of raw materials, and a number of production bottlenecks. The cost inefficiency is mainly a result of the inefficient use of grapes, which stand at an average of eight to nine kilograms per liter, as opposed to the ideal five to six kilograms. While the Supply Chain (SC) has been much explored in many analogous industries, such as wine, tequila, and beer, standing apart from this fact, academic literature does not consider the specific characteristics and difficulties inherent in the pisco industry. This absence of research concerning the sector indicates a meaningful gap in the existing knowledge. Another point concerns the unique design characteristics of pisco production functions. These characteristics complicate the successful delivery of the product. Included in this complication is the usage of artisanal methods, which are dependent on resistance to standardization. Unstable regulations existing in Peru are also a factor, and the reliance on small-scale grape producers maintains complications. It is a fact that comparable best practices as those applied in other global locations were impossible to adopt within this context. For example, the predictive models used for agave pricing in tequila [6, 7], or circular supply chain practice in wine [3-5] production are not applicable in the Peruvian setting. The need for specialized modelling stands as an important requirement for future academic analysis. While over thirty analyses address wine supply chain optimization and twelve are directed to the beer, only two studies concern pisco. This gap emphasizes the novelty of the present contribution. We propose a customized framework that combines VSM and PESTEL and MACTOR tools, which has been adapted to the artisanal production conditions and fragmented characteristics that are unique to Peru. The extensive literature review, which was undertaken as part of this research, has shown only two academic studies solely directed to the specific pisco supply chain. This is a very

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small number compared to the initial over thirty studies focusing on the wine supply chain. This demonstrates the essential need for a specific and customized industry strategy for this sector. This study bridges an existing gap in the literature by focusing on the structural inefficiencies of the pisco supply chain, as opposed to typical production problems or marketing strategies. The artisanal production process of pisco, together with the industry's complexities, makes it difficult to apply strategies from other types of alcoholic beverages. In this respect, the study introduces a new methodological strategy that merges engineering strategies with context analysis, thus offering a systematic strategy to enhance efficiency, sustainability, and coordination in the pisco supply chain. Contrary to other studies, this study seeks to merge qualitative engineering strategies like Value Stream Mapping (VSM), PESTEL analysis, and MACTOR analysis with expert validation strategies to ensure the validity of the data. The new strategy is context-specific and developed to address the fragmented and artisanal character of the entire pisco supply chain, and its applicability is one of its key differentiators.

The lack of a comprehensive optimization model that is adapted to the realities concerning pisco production shows the necessary requirement for a specific and targeted approach to this matter. This research is providing a response through the proposing of engineering-based solutions that are specially tailored for the constraints and opportunities of this sector, thus creating a connection between the theory and the practice. Through structured analysis of the supply chain, the aim is to reduce inefficiencies, enhance sustainability, and improve competitiveness for the companies. The entire production process is included in the scope of this investigation. This begins from the procurement of the raw materials, that is, grapes, until the final distribution of the product. Evaluation of performance indicators such as cost, time, quality, and risk is essential. The research implements a cross-sectional approach, analysing data in a defined time, so that we can capture the current state of this important sector.

It is, however, important to highlight that the heterogeneity of internal processes among pisco producers is a major limitation. This is especially the case when considering the issue of data availability and the standardization of data collection. The fact that this industry is mostly artisanal and the absence of common quality standards and documentation make it rather difficult to develop comparable performance indicators. Standing apart from these challenges, this study offers a valuable contribution to the understanding of this explored area. The contribution is through the application of a methodological framework. This is specifically adapted to the characteristics of the pisco industry. The framework maintains support by empirical validation and comparative analysis with other analogous sectors. This provides a structured, context-sensitive approach to supply chain optimization and management.

2. Description of the Sector and the Value Chain

Supply chain management encompasses all the activities necessary to produce and distribute a product efficiently. In Peruvian pisco production, this involves raw material management, planning and execution of the production process, inventory management, logistics, and distribution of the final product. In the Peruvian pisco production sector, the proper functioning of the processes that comprise the entire SC is considered essential. This is because it directly impacts the quality of the product to be produced throughout the entire process, from the receipt of raw materials to the handling, storage, and distribution of the product.

Below are the most common problems in the pisco sector. One of the problems is the low quality of certain companies' products and the informality of the market. Regulations and bodies responsible for overseeing the quality of the distillate have failed to stop the sale and consumption of adulterated pisco due to the low prices offered. This leads many people to opt for these products, unaware of the chemical components sometimes added. It is worrying that some manufacturers who use this practice have the designation of origin for pisco, which could affect the reputation of the entire category.

The quality decline in raw material, which resulted from the machinery utilization for harvesting and the post-harvest procedures, has impacted the ultimate quality of the final product. This decline also affects the profitability of individual farmers. Many farmers sustain a modest level of living. Moreover, the burden of taxes and production costs also contributes to this issue. These issues combined make it difficult for the industry to compete and make investments in improving processes and quality. Therefore, to improve the quality of life of farmers, the quality of products, and ensure sustainability and competitiveness, it is necessary to implement strategies to counter these issues. This is an important area for future development.

In the distribution phase of the supply chain, potential inefficiencies that have the potential to delay the delivery of finished goods are also present. These delays can encompass anything the company can or cannot control - such as strikes, traffic congestion, vehicle shortages, etc. These delays cause disruptions and have a direct impact on customers due to a lack of inventory at the store. Another situation is the high costs that can impact the profitability of a company, such as fuel prices and exorbitant rates from transportation providers. These increasing costs manifest in higher costs of production and profit margins. The warehouse link in the supply chain can have its own issues that can impact final product delivery. Storage problems can arise from improper organization and categorization, making it difficult to find products, which can delay shipment. There can also be problems in inventory control due to the lack of processes, programs, or people to get inventory control accomplished. This can delay determining what product should be ordered, as well as ordering from

suppliers. Picking errors can also be problematic in this link, leading to shipping incorrectly picked products or not picking a full order. This can lead to customer dissatisfaction and lost revenue.

Bringing products to market in the pisco category (in bars, restaurants, retail, etc.) also represents a challenge in several parts of the supply chain that continues to impact availability and efficiency. When products are not available to the consumer, the result can be lost sales and/or customer dissatisfaction. The shelf display can have several peripheral effects: it can reduce brand awareness (i.e., displays that are less than appealing, difficult to find, etc.). Brand exposure goes hand in hand with pricing strategies that may be instituted by the sales team and overall trade marketing dynamics regarding shelf display. Inventory issues include product shortages, product loss due to expiration, and/or the processing of inventory resulting in lost sales and profitability. It is important that companies are vigilant in collaborating with suppliers to prevent and remediate inventory loss issues by developing skilled inventory management and product availability processes at points of sale (bars and retailers).

Lastly, various issues can occur within the customer service wheelhouse that can frustrate satisfaction and thus, future profit margins on repeat purchases. The customer service team may not have the authority or power to respond to issues related to product quality, shipping quality that is purely external, etc. Also, delays in an external supply chain can be an issue. Furthermore, all of these can be even bigger issues if there is not a satisfactory process in place to manage returning products or complaints. A company must think about developing and have a process in place to be initiative-taking to resolve these issues when they arise, to maintain customer satisfaction. There are a number of indicators in the pisco production line that allow companies to monitor their performance in relation to achieving their goals. Similarly, however, these KPIs depend on factors such as demand, specifications, engagement in the target market of the product, positive reviews from the distributor or chain of supermarkets that sell the product, as well as the goals of the company. Since this is a sector-based research project, an attempt has been made to standardize the main indicators to communicate a global view of the selected sector. KPIs are an important part of assessing multiple key areas of the pisco production business, and they are particularly useful in the context of a research project.

They provide insights and opportunities on an array of cost-reducing and profit-optimizing matters, as well as resource utilization and quality manufacturing concerns. In addition, when they reflect the average sales value for each transaction, they provide useful information about consumer purchasing habits. Likewise, analysing per capita consumption allows us to evaluate and compare pisco demand in relation to the population, which is crucial for identifying growth and market penetration opportunities. These KPIs represent fundamental tools for strategic decision-making and continuous improvement in the pisco production business. The pisco supply chain has encountered a major challenge associated with the costs of production being very high.

So, this analysis maintains a focus on identifying both the direct drivers and the root causes that are contributing to the cost escalation within the whole pisco supply chain. For the systematic visualization of these cause-and-effect relationships, a problem tree will be developed, and we will apply the Ishikawa methodology. This is to identify the main problematic areas and their interdependencies throughout the entire supply chain.

SC Stage	KPI	Definition	Indicator	Unit
Supply	Raw Material Efficiency	Assesses the efficiency of the production process in terms of the quantity of pisco obtained per unit of raw material and quality standards.	5–6	kg/liter
Production	Production Cost	Measures the total cost of producing one unit of pisco, including raw materials, labor, energy, and other indirect expenses.	15	soles/liter
Distribution	Product Quality	Evaluates the quality of pisco in terms of flavor, aroma, and appearance.	3.3–3.5	grape pH
	Damaged Products (%)	Determines the percentage of products that arrive at the warehouse under non-optimal conditions.	2	%
Storage	Inventory Turnover Time	Measures the average time required for a product to leave the warehouse after being received.	60–90	days
Sales	Per Capita Consumption	Used to analyze and compare the consumption level of a specific product or resource in relation to the population.	0.45	liters per capita
	Average Ticket	Measures the average sales value per transaction, i.e., the average expenditure per customer purchase.	80–120	soles/purchase
Customer Service	Response Time	Measures the elapsed time from the moment a customer requests information until the company provides a response.	0.08	days
	Delivery Time	Measures the elapsed time between order placement and delivery of the product to the customer.	3	days

Fig. 1 Key performance indicators in the pisco production supply chain

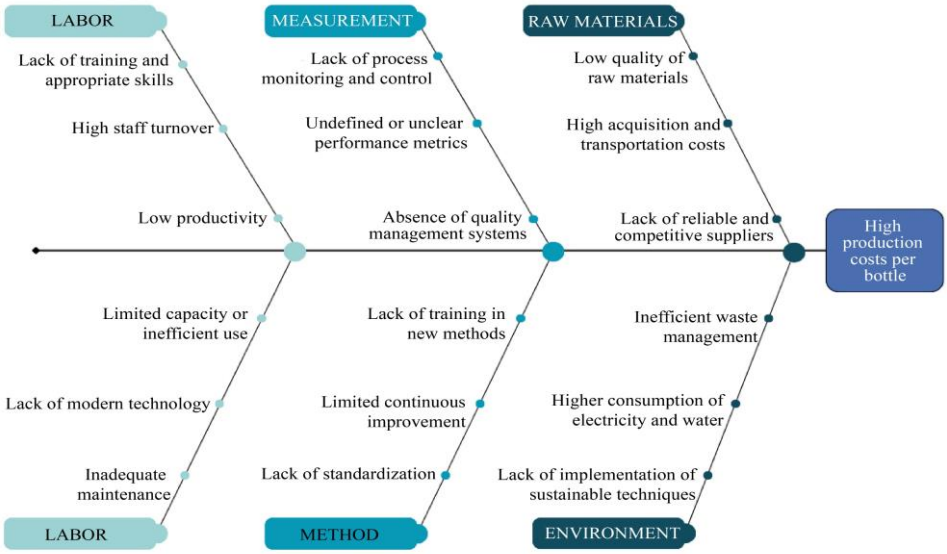

Fig. 2 Ishikawa diagram – high production costs per bottle

3. Sectorial System Analysis

In the case of pisco, the supply chain initiates its progress involving grape selection and extends through distillation, storage, and delivery to points of sale or export. Each stage is interconnected, so a deficiency at one level tends to affect the entire process. Producers frequently mention two difficulties that are recurring. The first difficulty is concerning the maintenance of uniform quality across small-scale production. Second is the persistence of informality that complicates the traceability ability. Standing apart from this, it is notable that in Morocco, the automotive industry achieved a reduction of delivery delays after the usage of Value Stream Mapping (VSM) for the detection of bottlenecks. This comparable approach, adapted for this present research, could facilitate the reduction of inefficiency found in distribution and thereby strengthen general competitiveness.

The technical gap that is identified within the sector is not only a qualitative issue, but it is also a quantifiable matter. For instance, the conversion ratio of average grape-to-pisco in the artisanal production stands at 8.5 kilograms per liter, in comparison to the optimal ratio that is 5.5 kilograms per liter. This inefficiency alone is responsible for an increase of 40 percent in the costs of the raw materials. In addition, the lack of standardized procedures in post-harvest handling and the use of outdated distillation technology are also factors that contribute to the quality differences and high waste generation. These factors should be standardized to make improvements in the future. The authorities responsible for auditing the quality of distilled spirits face difficulties in suppressing the sales of pisco when there is adulteration or when there is aggressive pricing. This is a complex situation that is reflected in the pharmaceutical industry, where companies use Value Stream Mapping to reduce the time elapsed in relation to compliance documentation by forty percent and use PESTEL analysis to forecast changes in regulations. The lack of standardization in the manufacturing process has led to a significant amount of variation in the quality of the product. Another challenge is related to the quality of raw materials, which has been driven by worries about harvesting equipment and post-harvest processes, as well as high production costs. This is in line with the challenges faced by Spanish dairy cooperatives, which managed to lower product spoilage by twenty-two percent by carrying out an in-depth analysis of the supply chain. For distribution stages, some of the issues that are apparent are delivery delays caused by factors outside the company's control and increased costs, which impact the company's profitability. The deficiencies in the warehouse also contribute to delivery delays and customer dissatisfaction, particularly with respect to the lack of organization and management of the inventory. These issues in logistics are reflected in the Moroccan car case study, where the strategic routing and alignment of interests of stakeholders, through MACTOR analysis, resulted in significant improvements. In addition, there are challenges that have been identified at the retail level. These include the unavailability of products and poor product display, which influence the visibility of the brand and the profitability of the products. Key Performance Indicators (KPIs) are important tools that can be used to measure the performance of the industry in this respect. The KPIs were standardized in all case studies. The major issue studied is the high production cost per litter of pisco, which is due to political issues causing inflation and uncertainty, which has increased the cost of raw materials. The average production cost per litter is currently twenty soles (approximately 5.61

USD), while the experts note an average cost of fifteen soles per litter (4.21 USD), representing a significant opportunity for improvement that could be undertaken following the methods employed in the other similar industries. There is a cost to the economy associated with the inefficient grape management, increasing production costs, and potential impacts on the profitability of the industry, and an additional unnecessarily high cost to consumers at over 75% above the standard cost; this could require raising prices to remain viable, thereby negatively affecting profit margins in order to be market competitive. Further, as grape production is intensive, there are also concerns regarding a water scarcity issue, adversely impacting the quality of the final product. The excessive cost related to grape utilization can impact the competitiveness of the company against others who produce pisco. Matter if the high expense reduces profit margins significantly.

It is necessary to find suitable ways for addressing these supply chain impediments and making improvements to the critical key performance indicators. This action could enhance the overall competitiveness, sustainability, and quality of the entire Peruvian pisco industry sector. The cross-industry case study examples illustrate that similar challenges have been overcome previously through the use of certain tools. These tools are often utilized for supply chain analysis and include Value Stream Mapping, PESTEL analysis, and MACTOR application. Such mechanisms are concrete suggestions that facilitate optimization of the pisco supply chain operations. The study highlights the economic importance of the alcoholic beverage sector in Peru, and it is a true fact that strategic policies are a necessity for overcoming the current challenges. This process of overcoming challenges benefits farmers and ensures product quality and secures the long-term sustainability of the industry through methodologies that are proven and adaptable.

4. Literature Review

Several authors have examined the policies of optimisation regarding the supply chain of alcoholic beverages. The method applied follows the SLR method [13]. This study spans from 2015 to 2022 and is focused on four key research questions: 1) What kind of academic output applies optimisation policies to supply chains? 2) Who is behind such policies? 3) What kind of policies are applied, especially to the optimisation of supply chains regarding the production of alcoholic beverages? 4) What kind of effects or evidence of impact are produced by the application of such policies?

Following the PRISMA guidelines on systematic reviews, a combined total of 597 studies were identified from two databases: Scopus and Web of Science. Application of screening criteria to studies dealing with alcoholic beverage suppliers and addressing optimization strategies within the period 2015-2022 resulted in 40 eligible studies. Of these, 75% focused on wine production, 15% on the production of beer, and 5% on other beverages, such as tequila or pisco, where Peru was among the revisited studies. It can be observed from the selected publications that 2017 was the year in which most research activity was It can be observed from the selected publications that 2017 was the year in which most research activity was concentrated, with around 65% of the articles framed in a pre-pandemic context. Geographically, the literature is mainly contributed by Western Europe, particularly Spain and Italy. In thirty of the forty cases analyzed, the central focus was wine production and distribution. Different optimization techniques have been applied to various supply chain processes of alcoholic beverages. There are five articles, each describing relevant strategies for CSCM, GSCM, SCND, and SSCM.

Recent literature (2022–2025) focuses on digital transformation and sustainability in agro-industrial supply chains. The application of blockchain and IoT technologies has enhanced traceability in the wine and beer industries, reducing losses to almost 10%. Circular economy approaches are focused on valorizing by-products, particularly in the production of artisanal beer and tequila. In the European Union, the Farm-to-Fork initiative is a good example of regulations encouraging environmental performance and traceability. The adoption of such advantages is still lower in some artisanal sectors, such as pisco. The methodological approaches most resorted to in the planning and formulation of the project were linear probability models, optimization models, and structural equation models. These studies also indicated the positive contribution of supply chain practices in improvement regarding efficiency, effectiveness, and quality.

The forty selected articles were distributed across the years, 65% of them published between 2015 and 2019, while the remaining 35% are from the COVID-19 pandemic, starting from 2020. In addition, the publication of the research was through academic journals and conference proceedings. Thirty-five articles were published in prestigious journals, while the remaining five were published in conference proceedings. Sources are from twenty-six journals and four proceedings, including Advances in Intelligent Systems and Computing, Lecture Notes in Computer Science, Springer Proceedings in Mathematics and Statistics, and CEUR Workshop. An in-depth analysis of the countries contributing to the selected studies unveiled a dominance of seventeen cases in Europe (Spain, Italy, Portugal) and eight cases in the Americas (Chile, U.S., Mexico, Peru). The distribution of alcoholic beverages was studied.

Analysing the methodologies and strategies used in the studies, each study used a specific methodology or strategy to overcome the challenges of optimization. The strategies used included interviews for extracting data, as well as more technical strategies like CSCM, SCND, and SSCM. The effects and findings from the implementation of these strategies were documented systematically. The compilation

is done through the description of positive results on efficiency gains, effectiveness, and the overall improvement of quality in processes involved in the supply chain for alcoholic beverages. Through the review of the literature, this paper provides an overview and detailed analysis of the scientific production, the research context, the categories of strategies employed, and the impacts and findings arising from the application of optimization strategies in alcoholic beverage supply chains.

No.	Impacts or Findings
1	Improvement in vertical coordination and reduction of difficulty in measuring grape quality.
2	Enhancement of operational coordination through relational behaviors.
3	Increase in service-level indicators, reduction of batch sizes and associated costs, improvement of product flow, and reduction of rejected orders due to delays.
4	Greater capacity to capture national added value by making the supply chain more service-intensive and by employing state-of-the-art production techniques.
5	Increased efficiency due to higher operational performance following alignment with an integrated model.
6	Increase in expected opportunity cost due to reduced demand uncertainty and non-significant increase in opportunity cost under certain situations.
7	Reduction of lost sales (4.9% → 2.5%) through total transparency, and average reduction of beer deterioration by 70%.
8	Need to apply different coverage strategies to satisfactorily manage product flows along the supply chain.
9	Reduction of transport waste and overproduction due to improvements in supply chain infrastructure and monitoring.
10	Reduction of pollution and promotion of resource-use efficiency without losing supply chain operations management perspectives.
11	Increased effectiveness of problem-solving in technical and economic research fields through Data Mining.
12	Identification of improvement opportunities regarding water consumption, land use, and impacts on local communities.
13	Improved quality through on-time delivery of finished products and maximized economic benefits.
14	Minimization of costs and carbon emissions generated by transportation activities, along with maximization of social indicators associated with supply chain facility impacts.
15	Increased agility of the Supply Chain based on human resource capabilities.
16	Minimization of costs and carbon emissions generated by transportation activities.
17	Facilitation of the identification of inefficient and efficient processes within the supply chain, and improvement of their management, relationships, strategies, and associated objectives.
18	Increased response time in the production chain.
19	Identification of significant influence on the perception of food supply chain performance through relationship quality.
20	Improvement in supply chain efficiency through the development of trust with suppliers.
21	Identification of behavioral risk factors that positively influence adoption.
22	Proportion of support to decision-makers as well as researchers in designing and strategically planning supply chain networks by optimizing operating costs and conserving freshwater resources.
23	More efficient risk mitigation and improved supplier relationships through continuous analysis and management.
24	Increased potential for reducing greenhouse gas effects in the value chain by raising the BiB proportion from 29% to 59%.
25	Identification of the most suitable approach through the combination of CAPEX and OPEX cost models.
26	Significant indirect influence of environmental uncertainty on the use of ICTs by SMEs in the wine industry supply chain through contractual and relational mechanisms (contracts and social ties).
27	Improvement in efficiency indexes and successful problem-solving within processes that ensure a continuous production flow.
28	Significant increase in the probability of farmers becoming producers of high-quality grapes.
29	Acquisition of details regarding both the production and supply chains through a platform that ensures product authenticity verification prior to purchase.
30	Generation of inadequate raw material purchase orders due to errors in demand estimation and direct relationship between demand and suppliers.
31	Reduction of carbon emissions released into the atmosphere as a result of bottling plant operations located in the United States and the United Kingdom.
32	Significant increase in sales, EBIT, and profits of breweries utilizing direct sales channels.
33	Improvement of raw material and finished product quality due to the implementation of SWOT analysis to define and compare Italian agri-food supply chains.
34	Benefit improvement through futures trading reduces risk aversion among certain winemakers.
35	Cost reduction through contained investments and attainment of higher profit margins.
36	Adoption of proactive behavior aligned with environmental evolution and consumer demands, improving production quality and commercial strategy.
37	Large gap between the configuration of the existing supply chain and proposed scenarios in terms of costs and emissions.
38	Increase in environmental benefits and annual improvement of economic profits.
39	Enhanced understanding of supply chain functioning and increased recognition of drawbacks or potential risks involved.
40	Minimization of overall inventory costs through the implementation of a policy that balances inventory holding costs and backorders.

Fig. 3 Impacts or findings in the supply chain

5. Applicable Standards and Norms

According to Directorial Resolution No. 072087-DIPI of December 12, 1990, and Supreme Decree No. 001-91-ICTI/IND of January 16, 1991, the Designation of Origin. "Pisco" is reserved and only authorized for products that meet the characteristics described in the relevant regulation and in this regulation.

The regulation on the Designation of Origin of Pisco states that this product may be produced only by the distillation of newly fermented musts from "Pisco Grapes," using techniques that preserve the product's traditional quality. It also states that the production of Pisco will be restricted to the coastal areas of the departments of Lima, Ica, Arequipa, Moquegua, and the valleys of Locumba, Sama, and Caplina in the department of Tacna (Resolution No. 002378-2011/DSD-INDECOPI, 2011).

This regulation defines the explicit criteria and parameters that producers must meet for their spirit to be recognized as Pisco. Any product outside of the limits set by this ruling cannot be marketed or labelled as "Pisco." Compliance with these requirements is vital to maintain the authenticity of Pisco as a traditional Peruvian product. Pisco is manufactured in a specific geographic region using both aromatic and non-aromatic grape varieties. The juice of these grapes is fermented completely or partially, without aging, and is then distilled in copper pot stills or falcas through a discontinuous process. Retort distillation and re-distillation are not permitted. After distillation, Pisco requires an aging process of at least three months in neutral containers before bottling. These strict requirements ensure the authenticity and quality of the product, which is an important part of Peru's cultural heritage. In addition, Peru's technical specifications provide guidelines for best practices in Pisco manufacturing, emphasizing quality, safety, and competitiveness without compromising the interests of either manufacturers or consumers.

The Technical Standard No. NTP 212.033, titled "Alcoholic Beverages. Pisco. Good Viticultural Practices," establishes the best practices for the cultivation of Pisco grapes and the production of Pisco, taking into consideration the safety of the product, the environment, and the working conditions. The standard covers the entire process, from agroecological zoning to the harvest of the grapes, and is applicable to both existing and new vineyards. It considers a series of key factors, such as soil management, grape varieties, fertilization, irrigation, crop protection, solid waste management, legal status of the farm, and working safety, among others (INACAL, 2021). In the same manner, the Technical Standard NTP 212.034, "Alcoholic Beverages. Pisco. Good Manufacturing Practices," provides the standards for ensuring hygiene throughout the entire process of Pisco production until it reaches the final consumer. This standard includes the entire process, from the harvesting of grapes to bottling, which involves winery hygiene, cleanliness in product processing, protection of the environment, and the reduction of risks to human health (INACAL, 2021).

6. Research Method

To guarantee a coherent structure of the research objective, the paper is divided into the following sections: the introductory section will diagnose the pisco supply chain, pointing out the main inefficiencies and problems; the second section will make a literature review on supply chain optimization, highlighting the gaps and possible applications; the third section will describe the methodology, focusing on the qualitative methods of VSM, PESTEL analysis, and MACTOR; the fourth section will show the results and strategies, whose validity will be evaluated by experts; finally, the discussion and conclusion sections will summarize the results, analysing their implications and suggesting future lines of research. Each section has been designed to progressively set up a framework that can contribute comprehensively to enhancing the efficiency and sustainability of the pisco supply chain.

The problem-evidence-impact-cause-tools framework is presented, with the aim of developing solution techniques for the identified problem. This tool identifies the main problem detected in the supply chain of bottled pisco in the one-liter format, related to high production costs. Evidence is given about the average cost of the sector, the benchmark standard value, and the relevant impact in percentage terms. Two basic causes are given based on the detected problem, and these were treated using established tools to address the face and mitigation of the problem.

The research conducted was of a non-experimental nature, with an applied qualitative approach to obtain profound knowledge concerning the case study through sectoral analysis. After determining the main problem present in the Supply Chain (SC) of the pisco production sector, the first causes and their respective root causes were determined. Engineering tools that could reduce the impact of the problem or find a solution to it at the cause were also found. Among these tools are the methods for determining the improvement solutions and their performance evaluation, such as Value Stream Mapping (VSM) and the Reigner Abacus.

The main problem found in the SC of one-liter bottled pisco is the high cost of production. To state this, the sector's average cost is given along with the benchmark value and its impact in percentage terms. Two fundamental causes were found that created the problem, for which specific tools have been used to solve it. The methodological framework is divided into three stages or substantial elements: firstly, diagnoses and identification of relevant factors and stakeholders; secondly, strategic proposals that improve the problems detected; and finally, the validation of the formulated proposal.

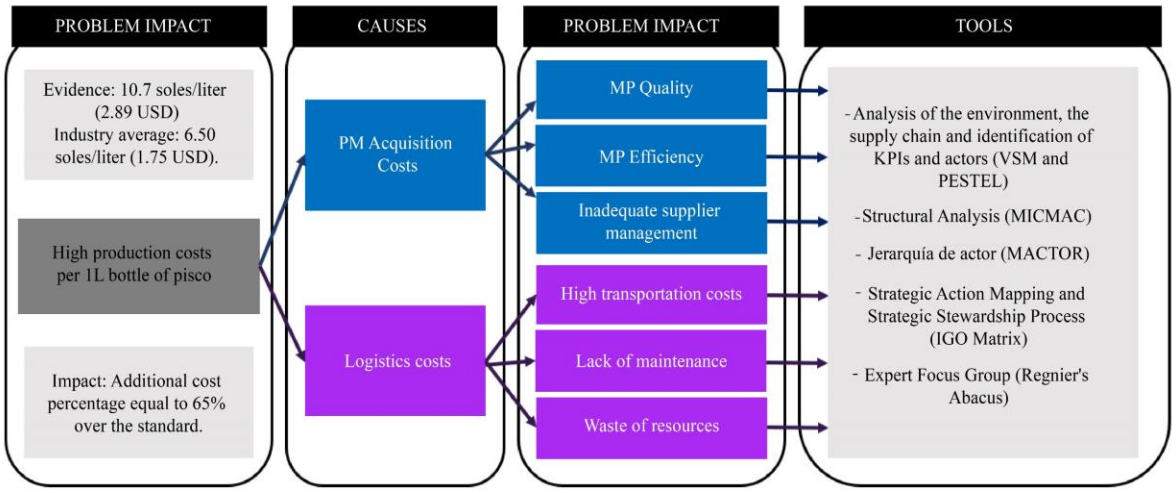

Fig. 4 Problem-cause-tool framework

Phase	Scope	Techniques or tools	Validation strategies
Phase 1	Diagnosis and identification of key factors (indicators) and actors.	Analysis of the environment, supply chain and identification of KPI's and actors (VSM and PESTEL).	Confirmation with experts
Phase 2	Strategic proposals to address the problems identified based on	Structural analysis	Triangulation
Phase 3	Lean Manufacturing, JIT, CS analysis, standardized work, autonomous maintenance, circular economy, etcetera.	Stakeholder hierarchy (MACTOR)	Confirmation with experts

Fig. 5 Structure of the methodological design

To achieve this requires an in-depth contextualization, we chose ten experts with over ten years of experience in pisco production and regulation. Data validation techniques were used, complementing interviews with official reports due to the risk of bias. For conversion rates of grapes and cost per liter of production, descriptive statistics were obtained for the mean and standard deviation.

The selection of interviewees was done based on prestige, track record, and specialized knowledge to make sure that the necessary information was provided in detail. Furthermore, it should be emphasized that the present research does not aim to produce statistical generalizations, but rather to make sure that the insights obtained are relevant and profound through the proper selection of participants. A validation committee was organized in order to obtain objective and comprehensive information from these experts, chosen so that their points of view were complementary. In such a framework, sample representativeness was not a priority; rather, the quality of participants relied on their experience and specialized knowledge of the pisco sector. The following shows the components or phases defined within the study, together with their explanations, and the techniques or strategies that were used to validate the respective phases.

6.1. Phase 1: Diagnosis and Identification of Key Factors (Indicators) and Key Stakeholders

In Phase 1, four specific techniques or tools were employed, namely: Value Stream Mapping (VSM), PESTEL analysis, structural analysis, and the Macro-Causal Tree and Operational Research (MACTOR). Regarding the PESTEL analysis, the scope of the study was limited to this sector of the economy; after that, the examination of the environment was done. Relevant information from this process was collected and treated with factor analysis, as seen in the analytic framework. As for VSM, the objective of the study

was established, and the relevant processes and their actors were highlighted. Performance metrics were established, and all the data required for graphical representation were collected. For structural analysis, an automated Excel tool was used, which was very useful for the later development of the MACTOR analysis. In this regard, the actors were hierarchically positioned based on their influence; their attitudes towards objectives were described, as well as the convergences and divergences. Subsequently, these analyses were later validated by consulting with preselected experts. If the experts corroborated the information obtained, the phase was considered closed. In the case of a negative answer, necessary corrections were made in the respective analyses to guarantee the quality and veracity of the results.

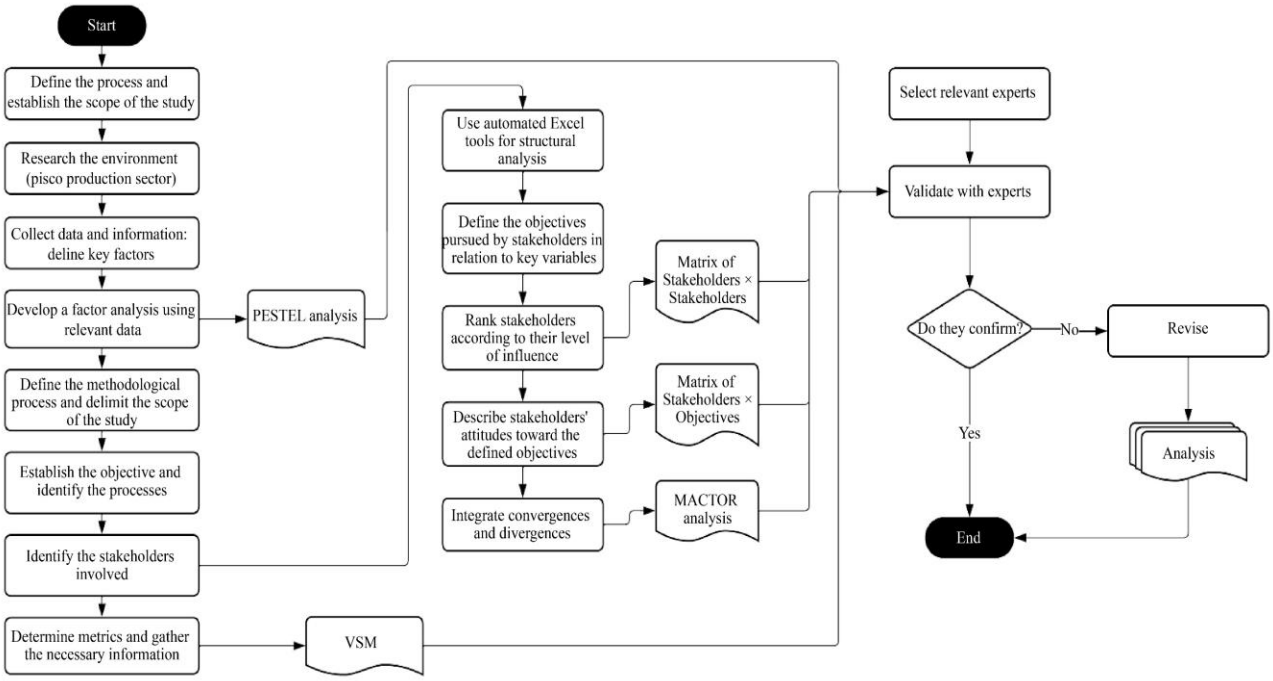

Fig. 6 Phase 1 flowchart

6.2. Phase 2: Strategic Proposals to Address the Identified Problems

In the second phase of the research, a strategic action mapping technique and strategic management process called the IGO Matrix were employed. This approach utilizes foresight to determine which strategies, objectives, or variables should be prioritized.

Initially, the target process and problem within the context of the research, specifically within the pisco production sector in Peru, were identified. The next step was to identify key dimensions related to the issue as a foundation to consider whether such dimensions could subsequently be placed in a matrix with three fundamental sections: Importance, Degree of Control, and Opportunity.

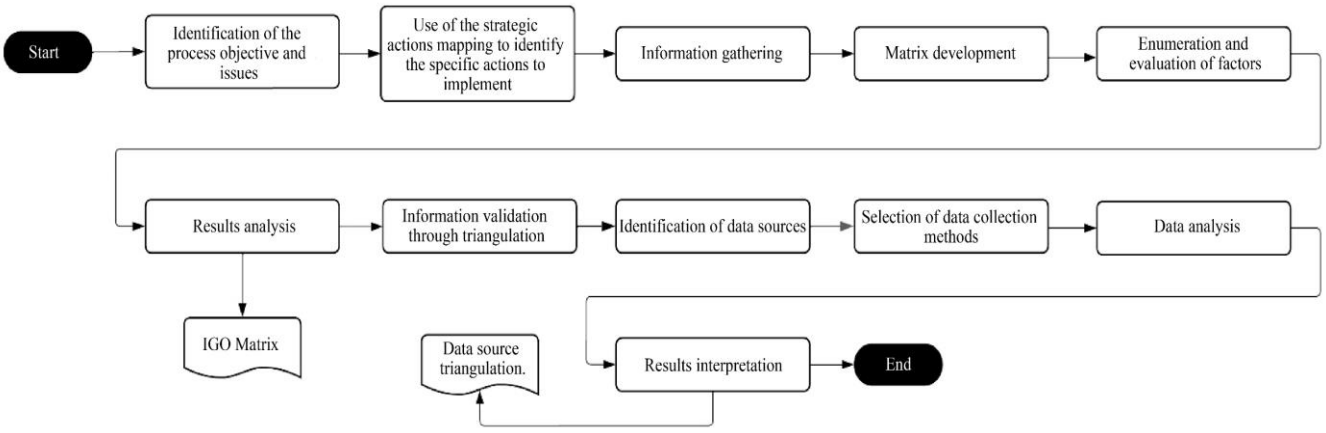

Fig. 7 Phase 2 flowchart

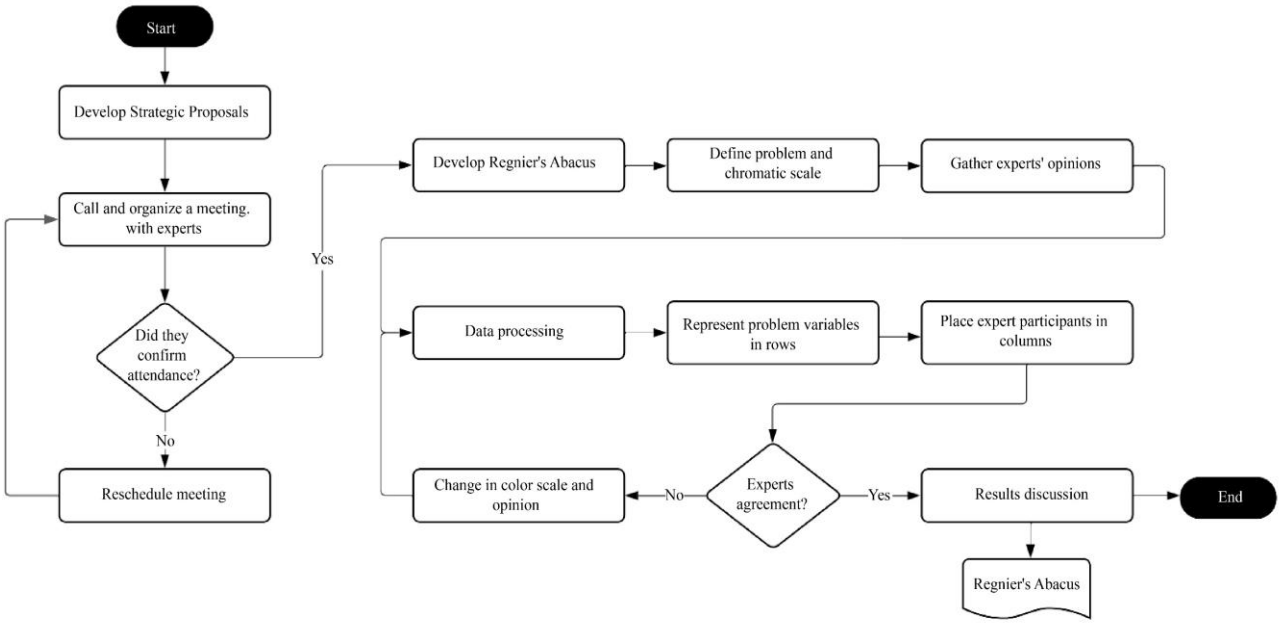

Fig. 8 Phase 3 flowchart

In the Importance section, in order, the dimensions that were identified previously were crafted into a list. Once the concern was identified, some determination of Degree of Control and Opportunity based on some scale or scores was employed. This step enabled some form of rational identification of the previously identified dimensions in the first step. The process was a validation using triangulation data to help with the validity and reliability of the findings. Various data sources were identified based on thinking through the various types of relevance of the information that needed to be collected and analysed. Once all data were complete, methods of individual interviews, focus groups, or a constructed questionnaire were selected to provide a broader lens for the study. Quantities of data were recorded and subsequently analysed. Then, methods or processes of comparison or contrast between data databases, or methods were selected to look at what data seemed to converge or diverge. Finally, in the analysis and interpretation of the collected data/context, trends or patterns were exemplified in units of data context collected, and where required, saturations or co-occurrences of the similarities across various data sources.

6.3. Phase 3: Validation of Proposals

In the research's third phase, the Reignier Abacus proposal validation technique was implemented immediately after developing strategic proposals and inviting and gathering experts. After the structure was established, the tool was applied as a method of consulting experts in the pisco production sector. The problem to be analyzed was defined, and a chromatic scale was established detailing the meaning of each color used in the opinion collection process. Subsequently, opinions from experts were gathered, providing their perspectives on the subject. Following data collection, the obtained data underwent processing. It is noteworthy that experts had the freedom to modify their responses on the chromatic scale and justify any changes in opinion at any point during the process. Finally, the results were analyzed by a structured debate where each member expressed the basis of their vote and the related decisions. The deliberative process allowed for a much deeper and better-founded understanding of the strategic proposals analyzed.

7. Application of Engineering Standards and Regulations is Required for the Design

The technical standards NTP 212.033 and NTP 212.034, "Alcoholic Beverages. Pisco. Good Viticultural Practices," previously referred to, were applied throughout all three phases of this study as general specifications for growing Pisco grapes and producing Pisco throughout these three stages. Their purpose is to guarantee food safety and hygiene and the protection of the environment, as well as the health and welfare of workers, to obtain a quality product. These standards cover the entire process, from agroecological zoning and site selection through grape harvesting and product bottling. They provide guidelines both for the established and new vineyards on managing soil, Pisco grape varieties, fertilization, irrigation, crop protection, solid waste management, and occupational health and safety, among other critical factors (INACAL, 2021). NTP 212.033 particularly emphasizes the importance of hygienic winery practices, process cleanliness, environmental preservation, and minimizing risks to human health (INACAL, 2021). These standards will be further examined in Phase 1 of this study through a PESTEL analysis, focusing on legal and environmental factors to establish regulations and guidelines

that ensure Pisco's quality, authenticity, and safety as a traditional Peruvian product, while also protecting the environment and safeguarding the health and safety of workers and consumers. Additionally, Resolution No. 072087-DIPI and Supreme Decree No. 001-91-ICTI/IND define the Pisco Designation of Origin, in a normative framework that aims at preserving traditional quality principles, establishing clear geographic delimitation, and identifying the allowed grape varieties, including both aromatic and non-aromatic classes. Such regulations reinforce the authenticity and quality of Pisco as a traditional Peruvian spirit. They will serve to guide strategic actions, the election of key variables for Components 2 and 3 of this study.

8. Results

This section presents the results of the sectoral diagnosis and the proposal formulated with respect to the problems identified. It concludes with a detailed exposition of the hierarchy of the stakeholders involved and their influence. These results relate to the three initial practical steps described earlier in this section.

8.1. Value Stream Mapping

To identify relevant processes in pisco production, the methodology of Value Stream Mapping (VSM) was used. In this sense, it was important to establish measures to develop an evaluation of how well the different phases were performing and to collect relevant data to develop a visual map of the value stream. This is an encompassing visual of internal processes and how they relate. Importantly, this tool corresponds to Phase 1 of the design methodology framework. The implementation of the VSM focused on identifying critical processes in Pisco production. The evaluation process introduced metrics in all stages of the supply chain evaluation. The supply chain process revealed significant issues according to an Ishikawa, or cause-and-effect, analysis. Issues related to reliable suppliers with dependable enforcement to ensure the quality of raw materials. High transportation costs threaten the potential profitability of the supply chain, and further exploration of optimization of transfer methods, shipments, or suppliers without losing efficiency is needed. Another issue identified was the lack of a systematic approach to continuous improvement in processes. Recommendations were given regarding the use of sustainable practices and the application of state-of-the-art technologies widely available to minimize environmental impacts while concurrently improving operational efficiencies. Another key factor that has been identified as important is the need for monitoring and control throughout the supply chain. Early detection of any deviation or problem makes it easier to make decisions and take corrective measures. Training of plant employees on new methodologies and techniques is also recommended as a way of improving skills and adopting best practices. The management of waste in inventories is also considered to be a factor that has a negative impact on environmental sustainability.

8.2. Pestel Analysis

The Peruvian pisco industry is influenced by political, economic, social, technological, ecological, and legal factors. The PESTEL analysis carried out in the VSM framework provides relevant information about the macro-environmental pressures and the key elements of the Peruvian pisco industry. In terms of political factors, current procedural changes in Peru have impacted the regulation of pisco. Currently, government support for the promotion of pisco internationally is a positive factor in the industry. From an economic standpoint, the pisco exports are a significant part of the economic structure in Peru. While economic fluctuations may reduce the demand for pisco and other luxury products, the current trend in exports indicates the potential for significant economic importance, especially in the context of emerging markets. From a social perspective, the environment is ever-changing, with consumer behavior shifting to require constant changes in the supply chain based on sustainability issues and increased awareness about origin and performance histories. Demographic trends also indicate that these constant changes are in line with economic and cultural trends.

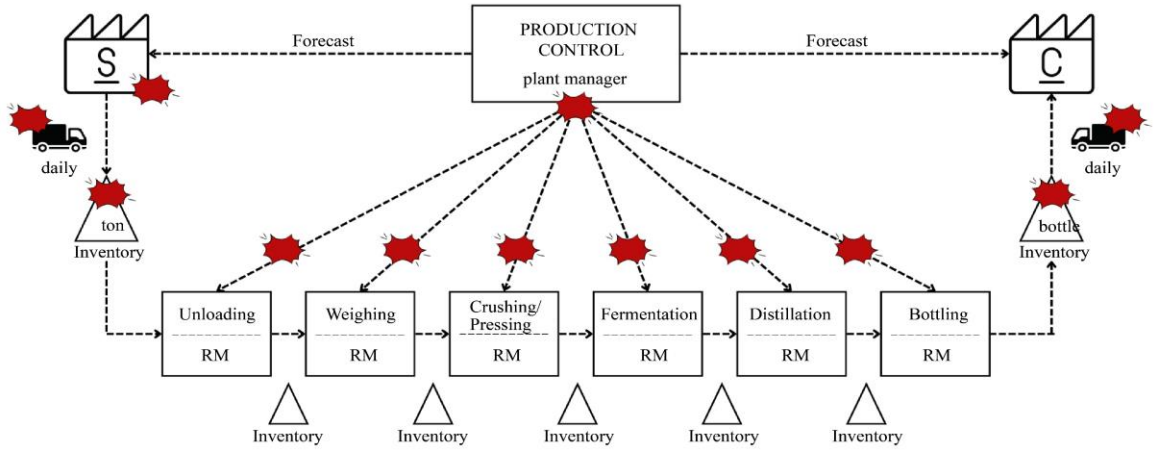

Fig. 9 Value stream mapping

In terms of technology, though the Peruvian pisco sector may be behind some parts of the world, there are ongoing projects that continue to give added value, especially in biotechnological investigation. Especially important is the response of the industry to the developing trend of e-commerce, underlined by the COVID-19 pandemic, which has evidenced the sector's capability to respond to technological changes.

From an ecological perspective, the sector demonstrates a willingness to invest in sustainable practices through renewable energy options and recyclable materials. This follows the global trend of taking care of the environment and adds to the goodwill that the industry enjoys from the public. Legally, continued compliance with the Denomination of Origin regulations will ensure the quality of pisco is maintained, and therefore, the industry remains competitive.

8.3. Structural Analysis of the Supply Chain

This study utilized VSM and PESTEL analysis to identify twenty-four codes along the political, economic, social, technological, legal, and ecological aspects of the Peruvian pisco industry. These codes were then reduced to fifteen variables, and this formed the basis for the structural analysis that was necessary for understanding the level of motricity and interdependence of the variables (see Table 2). Some of the variables include political instability, lifestyle, biotechnology, and government initiatives.

Table 1. Projection of variables (indirect impacts)

N°	Codes
1	Government openness to global trade and exchange
2	Change in government
3	Political stability
4	Economic cycles
5	Valuation of Pisco Exports
6	Demand
7	Labor force
8	Consumption trend
9	Demographics
10	Lifestyle
11	Introduction of new products
12	Technological development
13	Digital Transformation
14	Countries with a high level in the sector
15	Biotechnology
16	Government Initiatives
17	Concern for Environmental Preservation
18	Natural Alternatives
19	Water and Soil Pollution
20	Tariff Benefits
21	Legal provisions for quality assurance
22	New regulations
23	Informality
24	Modification of labor regulations

Further insights into these variables were provided, emphasizing their impact on the studied context. For example, Political Instability has impacted the pisco industry, as demonstrated by recent political crises in 2021.

The change in lifestyle positively influenced alcohol consumption trends in Peru, according to Euromonitor International.

In another development, the research studied a Cartesian plane projection in which variables were classified into power zones, conflict zones, output zones, and autonomous variables.

The study revealed an understanding of variable interdependencies and key factors influencing the Peruvian pisco industry. The priority order of variables is derived from comparative analysis, which provides valuable insights for strategic decision-making.

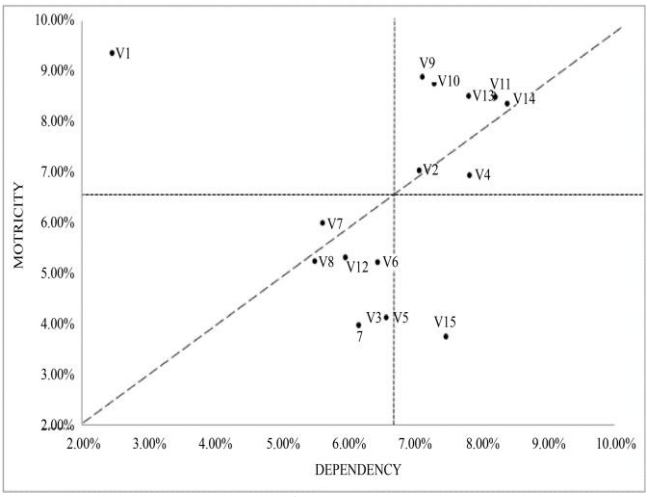

Fig. 10 Projection of variables (indirect impacts)

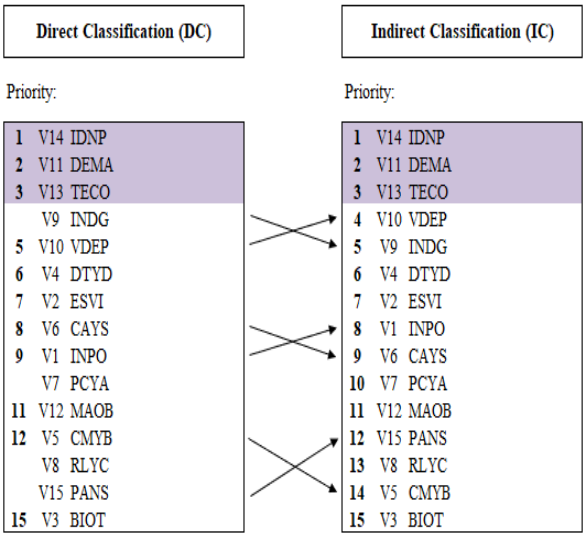

Fig. 11 Comparison of the priority order of variables

Table 2. List of variables and etiquettes

Label	Variable	Code
INPO	Political Instability	Change in government
		Economic cycles
		Political stability
ESVI	Lifestyle	Demographics
		Lifestyle
BIOT	Biotechnology	Biotechnology
DTYD	Technological and Digital Development	Technological development
		Digital Transformation
CMYB	Environmental Awareness and Solution Search	Concern for environmental preservation
		Natural alternatives
CAYS	Water and Soil Pollution	Water and soil pollution
PCYA	Trade Polices and Tariffs	Government openness to global trade and exchange
		Tariff benefits
RLYC	Labor Regime and Negative Consequences	Informality
		Modification of labor regulations
INDG	Government Initiative	Legal provisions for quality assurance
		Government initiatives
		New regulations
VDEP	Valuation of Pisco Exports	Valuation of Pisco Exports
DEMA	Demand	Demand
MAOB	Labor Force	Labor Force
TECO	Consumption Trend	Consumption trend
IDNP	Introduction of New Products	Introduction of new products
PANS	Countries with High Level in the Sector	Countries with a high level in the sector

8.4. Measurement of Project Impacts on Society (relevant stakeholders)

In assessing the impact of social factors on stakeholders, the study used the online application MACTOR to explain the power relationships between social actors in the Peruvian pisco industry. The social actors included competitors, environmental groups, distributors, consumers, government, community, and employees. The Direct Influence Matrix (DIM) was developed and then verified by an expert in the sector, with the power value set at four (n = 4) to obtain indirect influences. The Cartesian projection showed the geographical location of the social actors (see Figure 12). The power hierarchy was established by evaluating the influence and interdependence of the actors. The actors were placed according to their ri* values, thus creating a hierarchical system. The government was placed at the top of the hierarchy with a strong influence in terms of regulation, promotion, and support of the pisco industry. Consumers were placed second, followed by their demand and preferences. Environmental interest groups also had a strong influence, indicating a great concern with sustainability. The number of adjusted strength coefficients (ri*) was eight, equal to the number of identified actors in the system. The government, the most powerful, plays an influential role in shaping industry activities through regulations. Customers, as the second most powerful, directly impact product demand. Environmental Interest Groups exhibit growing influence, especially in promoting eco-friendly practices.

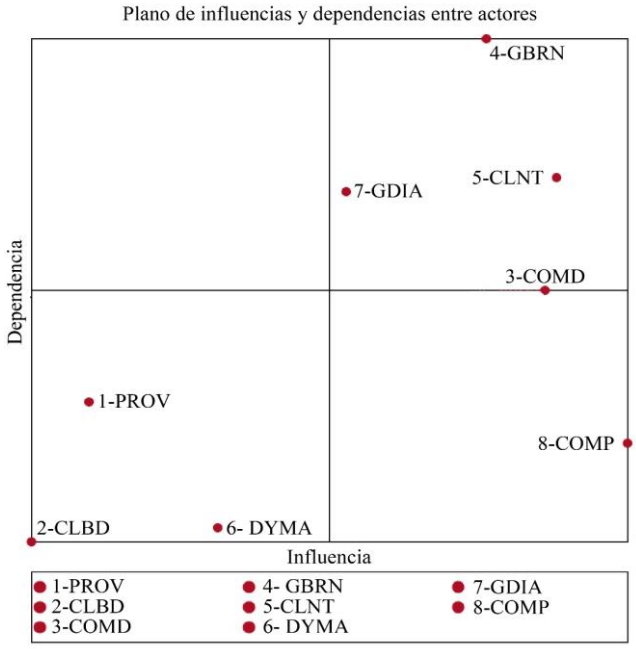

Fig. 12 Projection of stakeholders

Other actors, like suppliers, collaborators, distributors, and wholesalers, were assumed to have less power, though their contributions to the industry have real value. Supplier

power was recognized; however, their influence would be reduced more in comparison to the others.

8.5. Preparation of the General Scope of a Sector Plan

To formulate the sector plan, six strategies were elaborated, each addressing specific variable-actor pairs, derived from key variables and pivotal social factors identified in the structural analysis and MACTOR tool. The six strategies aimed at strengthening demand, intensifying sustainable consumption trends, capitalizing on government support of innovation, adapting to consumer trends, increasing customer satisfaction, and diversifying products through innovation. A full evaluation using the Importance–Governance Matrix (IGO) determined the best strategy for a given actor. For the government, Strategy 3, focusing on utilizing government support for innovation and product diversification, scored the highest average value compared to the others. On the customer side, Strategy 5 focused on greater customer satisfaction with the sectoral plan.

The initial plan, "New Product Introduction," stressed collaboration with the government to encourage innovation and product diversity. The purpose of this is to change the industry and diversify products while preserving the genuineness of Peruvian pisco worldwide. The second plan was addressing customers and demand, and was to boost demand and position in the market by creating customer satisfaction. It included improving the product, communicating effectively, having a corporate social responsibility front, increasing our online presence, and offering customer loyalty programs. An Abacus tool, which included expert ratings, had rated and ranked the proposed strategic actions above. It was an automated Excel program using macros to quickly and consistently engage in this assessment, reducing the risk of human mistakes. As a collaborative approach, this also means that there was a comprehensive and detailed assessment of the proposed solutions, which positively contributed to the trustworthiness of the findings. To summarize, the research included complex sectoral plans based on strategic actions and emphasized working hand in hand with the government and implementing customer-facing improvements. The thorough evaluation process, consisting of the IGO matrix and the Abacus tool, increased the proposals' credibility and quality.

9. Discussion

This section presents the findings of the research and provides a summary of the economic aspects. The aim is not only to point out the most important indicators but also to explain their strategic meaning and the implications that they may have in the pisco production sector. The role of Industrial Engineering is realized in the successful application of quality and sustainability management practices in the pisco production industry. This strategy has the potential to serve as a model for similar industries aiming for improvements in efficiency and quality. In addition, the proposed strategy, which is specific to the needs of the industry, indicates positive results not only in lowering the cost of production and improving financial performance through increased sales, but also in improving working conditions for those in the industry, including producers and farmers. The problem has been addressed by this research, which provides a complete solution to the challenges faced by the pisco industry.

9.1. Economic Evaluation

An analysis of the financial implications associated with the sectoral proposal was carried out. This was in relation to the cost of implementation and the level of investment that would be required over a period of five years (see Table 3). The financial performance indicators were also thoroughly analysed to establish the viability of investing in the proposed initiative. The Public Sector Budget Bill for Fiscal Year 2023 is US$54,515 million [14]. Of this allocation, US$36,222 million is assigned to the National Government, while Regional and Local Governments will receive US$7,562 million. This budget analysis provides essential data to understand how resources are distributed in the economic and fiscal context of the country. Regarding only the National Government's budget, which involves various entities and autonomous organizations, there is the possibility of obtaining US$971 thousand for the alcoholic beverage production sector, specifically for the pisco sector. This is due to the participation of the different ministries in this sector, such as the Ministry of Agrarian Development and Irrigation, which takes US$532 million; the Ministry of Foreign Trade and Tourism, with US$126 million; and the Ministry of Production, which receives US$159 million, including entities such as the Technological Institute of Production and the National Institute of Quality.

Table 3. Budget for the proposed sector plan (in thousands of dollars)

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Total
R&D	51	20	20	20	20	132
Product diversification	18	18	0	0	0	89
Promotion and marketing of new products	22	22	22	0	0	65
Technical assistance to producers	18	18	18	18	18	89
Human resources and specific capabilities	13	13	13	13	13	63
Quality certifications and recognitions	28	28	28	28	28	140
Quality improvement and production control	33	23	23	23	23	124
Communication and marketing	18	8	8	8	8	48

CSR programs	18	18	18	18	18	51
Sales channel optimization	38	28	28	28	28	112
Loyalty programs	18	10	10	10	10	58
Total	258	189	189	168	168	971

Considering the macroeconomic assumptions corresponding to the year 2023 were considered, establishing the average exchange rate of the dollar at S/ 3.94. This resulted in an estimated total investment of US$970,812 (see Table 4). The significant investment of resources in Research and Development (R&D) indicates a strategic priority on innovation and the development of current technologies, and investing in innovative products and processes that could drive long-term competitive differentiation. Further declines in R&D expenditure over subsequent years can be partly explained by the nature of the initial development phase reaching a more stable phase, therefore allowing the redistribution of resources to other key concepts.

In contrast, the upward allocation of resources to product diversification and the promotion of new varieties mirrors the strategic preoccupation with widening the customer base and testing new market outlets. Continued investment in quality improvement and production control demonstrates a commitment to a stringent quality standard, coupled with process optimization to meet market demands for maintaining customer satisfaction.

Table 4. Investment by ministries (in millions of dollars)

Concept	Budget	Investment
Ministry of Agrarian Development and Irrigation	486.47	0.58
National Institute for Agrarian Innovation	45.51	0.05
Total of the Ministry of Agrarian Development and Irrigation	531.98	0.63
Ministry of Foreign Trade and Tourism	67.23	0.08
Commission for the Promotion of Peruvian Exports (PROMPERU)	58.88	0.07
Total of the Ministry of Foreign Trade and Tourism	126.12	0.15
Ministry of Production	112.08	0.13
National Quality Institute	8.68	0.01
Production Technological Institute	38.32	0.05
Total of the Ministry of Production	159.09	0.19
Total	817.18	0.97

9.2. Limitations and Challenges

This study is subject to several limitations that must be acknowledged to contextualize its findings and guide future research properly. To begin with, the analysis is limited to variables and data from just one fiscal period, which limits any ability to observe seasonal variability, long-term tendencies, or the impacts of regulation or macroeconomic conditions over time. The thinness and lack of consistency of industry-specific datasets represent another challenge. While studies and literature exist providing robust data for the wine (Chaddad et al., 2017; Davis et al., 2019; Ferreira et al., 2019), tequila (Warren-Vega et al., 2022; Castro-Montoya et al., 2015) and beer (Bandaly et al., 2016; Hill et al., 2021; Ariemma et al., 2022; Balogh et al., 2021) industries, there is a lack of systemic, standardized representation of the pisco industry which inhibits systematic benchmarking, generalization of conclusions, or possible bias during improvement design. The artisanal nature of production also drives significant variation in practices, from grape sourcing to distillation and supplier requirements, commonly not allowing for consistent implementation of behaviour-managing quality assurance systems or performance indicators across the sector. To start, the investigation concentrates on elements and data from a single (fiscal) year, which restricts any opportunity for observing seasonal variability, long-term trends, or the influence of regulation or macroeconomic changes over time. Another limitation is the thinness and inconsistency of industry-specific datasets. Even where there are studies and literature that have robust data for wine (Chaddad et al., 2017; Davis et al., 2019; Ferreira et al., 2019), tequila (Warren-Vega et al., 2022; Castro-Montoya et al., 2015), and beer (Bandaly et al., 2016; Hill et al., 2021; Ariemma et al., 2022; Balogh et al., 2021). It does not appear to be the case for the pisco industry that a systematic, standardized representation of the pisco industry is missing, impeding systematic benchmarking, generalizability of conclusions, or potential bias during design improvement. Moreover, the artisanal nature of production causes a varied spectrum of practices from grape sourcing to distilling and supplier constraints; as a result, sector-wide consistency in the implementation of behaviour-managing quality assurance systems or performance indicators is typically not attainable.

This investigation employed a qualitative methodological approach, using approaches that are qualitative and validated by experts, while providing a rich amount of detail and context; it does not allow for statistical inference or predictive modelling. The sample of study consisted of three

representative wineries, two formal and one informal, which was intentional to capture variations production of scale and adoption levels of technology, but this approach dissipatedly failed to capture the full diversity of the construct, of the overall pisco sector in Peru, particularly, the many informal operatory or micro-level operations, that comprise a considerable amount of supply chain. Future studies should complement this exploratory qualitative design with quantitative modelling, larger sample sizes, and longitudinal data collection to enhance the robustness and reproducibility of findings.

Finally, the successful implementation of the proposed strategies faces further systemic challenges: fragmentary governance structures, complex regulatory environments, and limited coordination between public institutions, private stakeholders, and cooperatives all impede rapid change.

Financial constraints, including access to credit for small producers, remain a major barrier to investment in quality certifications, R&D, and advanced logistics infrastructure. Moreover, volatility in global markets, climate change impacts on grape production, and competition from other spirit industries introduce external risks that could undermine long-term planning and require adaptive strategies. These challenges highlight the importance of phased implementation, strong institutional support, and targeted investment policies to fully realize the potential benefits of supply chain optimization in the pisco industry.

9.3. Discussion of Results

For the validation phase of the sectoral proposal, the tool known as Regnier's Abacus, presented in section 3, was applied. In this process, experts were consulted and asked to evaluate each of the proposed strategic actions (see Figure 13). On a larger scale, it can be stated that the most valuable action was No. 5: "Implement rigorous production and quality control practices", aimed at increasing customer satisfaction in the pisco-producing industry in order to encourage demand and strengthen market position.

This action was unanimously rated as "very important". Strategy N° 4: "Collaborate with the Government to strengthen Certifications" obtained three ratings of "very important" and one of "important", being considered valid and accepted as a proposal for improvement. In contrast, strategy No. 7: "Implement Corporate Social Responsibility (CSR) programs" received only one "important" rating, but three "doubtful" ratings. This indicates that there are other actions that may take priority, and this particular action should not be considered as important for the final improvement, which focuses on reducing production costs.

	01 Expert 1	02 Expert 2	03 Expert 3	04 Expert 4
Very Important				
Important				
Doubtful				
Not Very Important				
Not Important				
No Response				
01 Government support for R&D programs				
02 Collaboration with the Government for product promotion				
03 Implementation of diversification policies				
04 Working with the government to strengthen certifications				
05 Implementing stringent production and quality control practices				
06 Establish effective communication channels				
07 Implement CSR programs				
08 Improve online presence and ease of use				
09 Create loyalty programs				

Fig. 13 Regnier abacus results

The relationship between budgeting and the results of Regnier's Abacus is also apparent in the allocation of resources to the priority areas that were identified in the analysis. For example, the stress that was put on the need to implement strict approaches in order to improve quality and control of production is in line with the recommendations identified by Regnier's Abacus, showing a strong understanding of the key needs of the sector. The analysis of the sectoral effect caused by the proposed implementations shows that the damage rate remains at 2% for products, as expected [15]. However, the efficiency of the Pisco supply chain shows a significant improvement, registering 5 kg/L in this study compared to 1,106 kg/L in other studies, thus confirming the positive impact of the proposed optimization strategies [11]. Compared to other studies, the findings on damaged products indicate convergence, indicating a stabilization of product quality in the sector. On the other hand, the improved efficiency indicates the effectiveness of the current proposal in improving the logistics and supply chain process of Pisco. This is attributed to the adoption of

new approaches and technologies in the field of supply chain management. The analysis of sustainable practices in pisco production explains the importance of sustainability in managing distilled spirits. However, the application of sustainable practices shows some differences based on the needs of the pisco industry. This flexibility, in theory, shows the ability to apply the practices in other industries, emphasizing the significance of place in sustainable practices [16].

Observing the influence of state regulations on the production of pisco and, in general, the pisco industry, we find a convergence of the influence of state regulations across the spirits industry [4]. However, taking into consideration the specific state regulations on the production of pisco, these regulations must function within a specific regulatory environment. The issue of whether these regulatory strategies can be generalized to other similar situations in the industry highlights the differences in regulatory environments and the generalizability of state policies. In tandem, the examination of international markets for Peruvian pisco finds familiar and successful approaches to entering markets abroad, thus confirming the importance of cultural promotion [17]. The similarities in approaches to pisco promotion are highlighted, with a focus on the importance of adapting these promotion aspects, which suggests a generalizability to similar situations when entering international markets.

Regarding evaluating the quality of Peruvian pisco through tasting and sensory analysis methods, the need for evaluation both objectively and subjectively is celebrated. It was pointed out, however, that evaluating quality objectively and subjectively should consider culture and local standards when implementing these evaluation techniques in the pisco sector. This emphasis on subjectivity reiterates the need to adapt evaluation methods once again, but with each product. Moreover, other types of technological innovations in the production variants of pisco improved the product quality and efficiency of production processes, directly correlating technology with the optimization of process products. By focusing specifically on technological innovations in pisco production processes, the discussion demonstrated how to adapt technological measures relating to quality and process based on the product and distillation type.

The perception of Peruvian pisco as a product in the international marketplace has been made out to be a central factor in the marketing of the beverage. However, regarding the perception of the Pisco Peru brand, the necessity of emphasizing its cultural authenticity and heritage when marketing the product in international markets has been mentioned [19]. The implications of marketing for brand management in the specific cultural context of pisco Peru indicated the significance of having strong cultural ties in the management of brand marketing for the purpose of global recognition and acceptance. Likewise, the results of digital marketing strategies to promote pisco in a domestic context demonstrated some similarity with the overall importance of digital marketing in the promotion of local food and beverage products [20]. The study centered on digital marketing strategies for pisco in a domestic context was also keen on emphasizing the importance of customizing campaigns around the nature of the consumers and their specific preferences, and their consideration for the local context. This indicated that successful campaigns using digital marketing may have some elements of relevance in context and generalizability if they are contrasted to and meant for the specific preferences and behaviours of the consumer.

The focus of this sector manual was to improve collaboration with the government and improve customer satisfaction with initiatives reflecting both groups of stakeholders. Some notable similarities in stakeholder valuation are evident in innovation, product quality, and effective communication with customers, framing the elements as useful approaches, as shown through established empirical methods such as JIT, Kaizen, 5S, and TPM, to improve operational efficiency and customer satisfaction across a variety of industrial settings [15]. While differences in optimization circumstances were indicated, emphasis was placed in the sectoral manuals, specifically, on innovation and product diversification related to applying the generic proposals in relation to the specific circumstances of the Pisco sector. Implementation of the sectoral manuals focused on demonstrating that not only were innovation, product quality, and effective communication with customers critical elements to position sector producers for an ongoing sustainable outcome, as evidenced across a variety of industries, but they also have potential impact and usefulness across various business cases or the alcoholic beverage industry overall.

Finally, the role of tradition, as well as the significance of safeguarding cultural legacy when producing traditional spirits, was illustrated [2]. The role of tradition in the production and promotion of artisanal pisco also emphasized the necessity of negotiating cultural authenticity as it relates to current market trends. Therefore, negotiating traditions and the present time encourages a level of cultural authenticity while being aware of evolving market demands.

10. Conclusion, Contribution, and Future Work

The findings of this research show that the use of industrial engineering tools, adapted to the Peruvian pisco industry, is an effective method to identify problems and provide achievable recommendations to improve supply chain performance. The implementation of a quality management system, together with efficiency and sustainability, has provided the necessary cost savings in the production process to improve the competitiveness of the sector. This research offers a validated optimization process for the artisanal production of pisco that achieves the expected cost savings and efficiency gains while preserving the current artisanal

production status. The combination of advanced analytics and traceability platforms improves competitiveness and export potential. Future research should include large-scale experiments, economic analysis (NPV, IRR) of the technology, and evaluation of the approach's validity for other artisanal products, such as rum and mezcal.

In addition, the study makes it clear that improving resource use efficiency and minimizing waste should be an integral part of the overall commitment to sustainable practices in pisco production. The study underlines the importance of training programs aimed at improving productivity for grape growers and suppliers. In this context, the training programs help improve the overall ability of the industry to withstand challenges and compete effectively in the market.

This research contributes to the literature by developing a methodological framework that combines qualitative analysis with strategic diagnostic techniques, such as VSM, structural analysis, and the Reignier Abacus. It is only through this combined approach that it is possible to identify relevant factors and prioritize strategic decisions with respect to stakeholder impact and organizational viability. While existing research often focuses on either quantitative models or specific technical solutions, the current research provides a specific, participatory model that reflects the artisanal and fragmented nature of the pisco industry. This research, from an industrial engineering point of view, shows how traditional approaches can be successfully transferred to environments characterized by strong craft production structures and structural realities. The proposed ideas regarding traceability, product quality, and interactions with producers and public authorities represent a transferable approach for other agri-food sectors that share similar characteristics. This research contributes to the existing literature by investigating a partially overlooked area of research and by providing a systematic approach to deal with the challenges relevant to this sector. It is necessary to note that there are some limitations that have been identified in the study. Given that the industry is artisanal and there is no standardized data, it has been difficult to carry out benchmarking and generalization of the study. Considering that the data used in the study is qualitative, it is necessary to point out that the methodology used in the study can be improved by carrying out qualitative analysis in the future.

Future studies should evaluate the proposed strategies using economic analysis, using financial metrics such as Net Present Value (NPV) and Internal Rate of Return (IRR) to form a more concrete conclusion about the return on investment potential of the strategies and the chances of their implementation. Also, applying the thinking of possible applications for these strategies to other traditional alcoholic beverage products (e.g., mezcal or rum) would give specific evidence to conclude the transferability of the model. In the future, an examination of further types of value creation to enhance operational efficiencies and customer experience in similar industries might be pursued. Finally, attention should be given to how cultural identity and authenticity-two important factors in traditional beverage product production-can be leveraged and enhanced to create a competitive advantage in the global market, without compromising quality and sustainability.

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