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Value Chain Optimization in the Costa Rican Medical Device Industry: Strategies for International Competitiveness

Johan Rojas[1], Karen Carranza[2] and María de los Ángeles Campos[3]

[1]*Independent researcher, Costa Rica*

[2]*Universidad Estatal a Distancia, legal department, Costa Rica*

[3]*Council of Ministers of Health, Central America and the Dominican Republic, El Salvador*

Abstract: The study "Value Chain Optimization in the Costa Rican Medical Device Industry" examines the optimization of value chains in Costa Rica's medical device industry to enhance international competitiveness. It emphasizes the significance of evaluating and refining value chain activities within companies to strengthen human talent, foster innovation, and improve operational efficiency. Utilizing exploratory and documentary research methods, the study integrates theoretical perspectives with practical industry insights, drawing on academic literature and reports from global organizations such as the World Bank. Key findings highlight the importance of strategic public policies, value chain mapping techniques, and digital transformation in improving supply chain resilience. The research also identifies emerging trends and industry megatrends through expert discussions, providing a comprehensive framework for future development. The results underscore the role of local supplier integration, regulatory compliance, and sustainable business practices in positioning Costa Rica as a leading hub for medical device manufacturing. These strategies are crucial for maintaining long-term global competitiveness in the sector.

Keywords: medical devices, value chains, international trade, Costa Rica, international value chains

1. Introduction

Costa Rica's unique geographic features, including coastlines on both the Pacific and Atlantic Oceans, position it as an attractive locale for international business ventures. The nation's high educational standards draw prestigious multinational companies, while its political stability and lack of a military foster a favorable environment for international trade.

Costa Rica's high educational standards draw prestigious multinational companies, while its political stability and lack of a military foster a favorable environment for international trade.

This stable economic, political, and social landscape, coupled with the country's strategic location, education system, and various legal frameworks that promote the medical device industry, underscores the necessity to evaluate the maturity of the value chain activities in this sector [1]. Such an evaluation is vital for grasping the current condition of the industry and foreseeing the future dynamics of the global value chain (GVC). See Figure 1.

2. Literature Review

The literature review employs exploratory and documentary methods to advance both theoretical and practical understanding of the topic. It emphasizes the assessment of the maturity of value chains within sector companies, underscoring the need to use value chain mapping techniques to optimize internal processes and the implementation of public policies that enhance competitiveness.

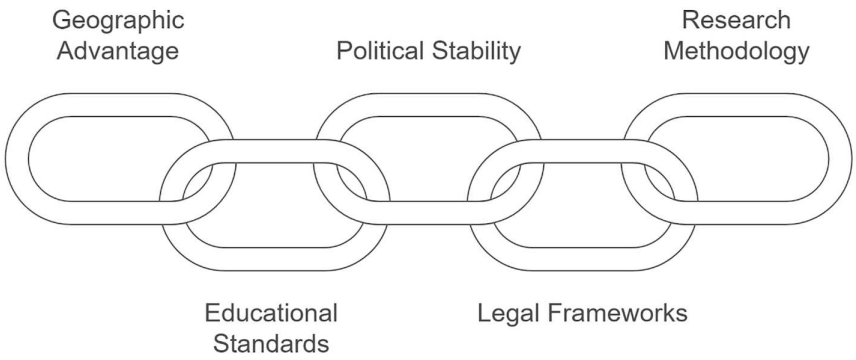
The reviewed literature includes a variety of sources ranging from academic studies to reports from international organizations such as the World Bank, providing a comprehensive theoretical and practical framework. Significant trends are identified, and megatrends are developed based on their prevalence in expert discussions. This holistic approach not only allows for an understanding of the current and future dynamics of the GVC but also contextualizes the medical device industry within the economic and competitive landscape of Costa Rica.

3. Methodology

The study uses exploratory and documentary methods to advance both theoretical and practical understanding of the research topic. Data were gathered through an online survey conducted on LinkedIn, targeting professionals in Costa Rica's medical device field. This method allowed for a quick and efficient collection of responses from 76 participants. Additionally, the research identifies significant trends by analyzing the recurrence of themes in specialized literature, aiming to develop six major megatrends based on their prevalence in expert discussions.

***Corresponding author:** Johan Rojas, Medical Device Industry, Costa Rica. Email: johan.rojas.rojas.e@icap.ac.cr

Figure 1
Factors of development in the medical device industry in Costa Rica



The study employs a mixed methodological approach, combining exploratory and documentary research techniques with specialized academic literature, aimed at providing a theoretical-applied framework to understand the dynamics and processes currently influencing emerging trends in the medical device industry in Costa Rica.

The choice of the exploratory method is justified by the need to identify and analyze patterns and trends articulated by key informant professionals active in the medical device sector in Costa Rica, in contrast to an analysis of specialized academic literature and sectoral document consultation. This facilitates a dialogue between empirical findings and existing academic discourse.

3.1. Research design

The study uses exploratory and documentary methods to advance both theoretical and practical understanding of the research topic. Data were gathered through an online survey conducted on LinkedIn, targeting professionals in Costa Rica's medical device field. This method allowed for a quick and efficient collection of responses from 76 participants. Additionally, the research identifies significant trends by analyzing the recurrence of themes in specialized literature, aiming to develop six major megatrends based on their prevalence in expert discussions. The concept of a GVC is further clarified with a diagram from the World Bank, simplifying the explanation for easier comprehension.

3.2. Participants

For data collection from the aforementioned survey, it was necessary to employ an online survey with a closed-response format, distributed via the professional platform LinkedIn. This allowed efficient access to a diverse group of sector professionals in Costa Rica, previously verified by the professional network. Despite utilizing non-probabilistic and convenience sampling, this method was deemed suitable given the specificity of the target group and the exploration objectives of the study. The survey reached 76 participants, providing a solid foundation for preliminary analysis, albeit with limitations in generalizing the results.

The collected data were analyzed using descriptive statistical analysis techniques to identify predominant frequencies and patterns. Additionally, thematic analyses were conducted to extract megatrends from the responses to ensure accuracy and objectivity in data processing. This allowed the establishment of two major themes for the development of this study: the first being the distribution of responses on critical factors for sector growth, and the second, the frequency of mentions of emerging trends and their potential impact on the medical device industry. While the sample size and sampling method have limitations, the findings provide an important basis for future research and for the development of strategies that promote the international competitiveness of the sector.

4. Results

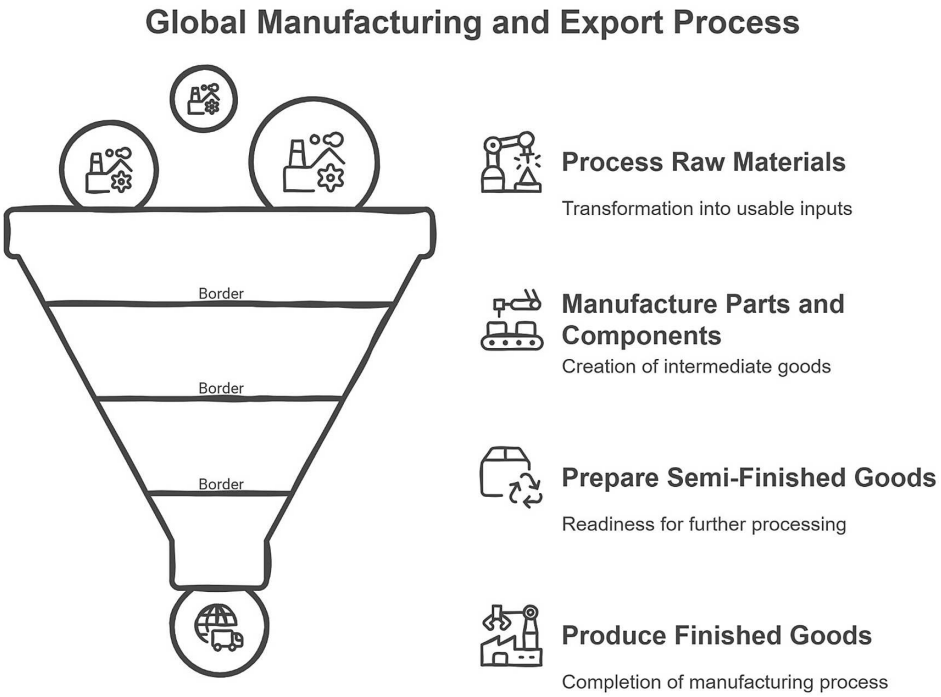
According to Lotfi et al. [2], one of the challenges facing supply chain designers is designing a sustainable and resilient supply chain network. The definition and general framework of GVCs have been detailed as products that are produced in different parts of the world, which we refer to as "multi-country products." The following figure, proposed by the World Bank, is used to explain in a very simple way what a GVC entails. See Figure 2.

Liu and Yang [3] determine that traditional value stream mapping (VSM) lacks the capability to handle conflicting factors in the improvement scheme and to prioritize multiple improvement initiatives. The historical events that led to the establishment of international trade, the legal sources that regulate it, and the technology that facilitates it make it possible to establish that the number of links in a value chain varies substantially according to the type of industry in question. "Chain activities are sometimes carried out by one company and sometimes by several" [4], and Liao et al. [5] determine that the particular model outcomes are discussed for a particular case. The findings reveal the most economically viable repair, since several sensitivity analyses are conducted to clarify the impact of operating revenue and warranty time. In the contemporary era, GVCs represent a prevailing strategy for the successful execution of the novel business requirements demanded by international trade. This strategy is applicable to a diverse range of industries. Adama et al. [6] suggest that the utilization of the Costa Rican Tourism Institute can serve as a crucial strategy in enhancing competitiveness. However, they are not exempt from experiencing significant challenges. The first is the automation of processes through emerging technologies and global conflicts such as trade and war [7].

To develop value chains, a production process identifies three essential aspects, according to Acosta et al. [8]: (1) inputs or raw materials; (2) transformation processes; and (3) products with value for the markets, for the modification of goods to make them suitable for meeting certain needs, that is, the addition of value to a good, product, or service as a result of a transformation.

The development of value chains in the medical device industry in Costa Rica, based on the aforementioned steps, allows the following panorama to be based on the outlined steps. Costa Rica's

Figure 2
What is a value chain, and what is its importance for commerce?



medical device industry has evolved significantly. As of 2024, the country boasts a cluster of 92 companies, according to the Costa Rican Investment Promotion Agency (CINDE). These firms create innovative technologies designed to improve human health, including devices for the diagnosis, treatment, and prevention of diseases. These medical tools and equipment are essential for detecting, measuring, and correcting bodily functions.

The objective of this paper is to analyze value chains, with a particular focus on the medical device sector in Costa Rica. It is essential to examine the significance of the medical device sector in ensuring the health, quality, and longevity of human life. This sector is witnessing a surge in international business activity, underscoring its pivotal role in modern healthcare.

In the Latin American region, the emerging markets for medical devices are of great significance. In several countries, this sector has experienced a rapid annual growth rate. With a few exceptions, countries import more than 80% of their medical devices. Consequently, ensuring patients have access to high-quality, safe, and effective medical devices is a priority for countries [9].

The life sciences industrial sector in Costa Rica has the following characteristics, as determined by CINDE [1]. See Table 1.

The Costa Rican medical devices cluster has the potential to establish the country as a significant high-tech export market in Latin America, given its human, industrial, and market resources. The potential economic impact is significant, and the industry has access to a global market of potential consumers. Furthermore, the industry has the potential to develop in an environmentally friendly manner.

Costa Rica has seen significant expansion in its medical device sector. By the first quarter of 2023, these devices accounted for a substantial 41% of the nation's total exports. As stated by the Pan American Health Organization: Medical devices are considered a fundamental component of health systems. The benefits they can provide continue to increase as they are essential to prevent, diagnose, treat, and rehabilitate diseases safely and effectively (n.d.).

GVCs facilitate accelerated industrialization in developing countries, such as Costa Rica. GVC integration enables these

Table 1
Medical device cluster in Costa Rica

Characterization of Costa Rica's Medical Device Cluster	Description
Cluster	The cluster comprises 92 companies that are currently engaged in the production of medical devices (MD), which has positioned this product as Costa Rica's primary export commodity. At present, 13 of the 30 medical device manufacturing companies, including the global leader in this sector (Medtronic), are based in Costa Rica. The San José-Heredia Metro Area has been identified as the most competitive city in Latin America for life sciences, according to a 2018 study by Site Selection Magazine. In 2018, the World Bank determined that Costa Rica was the leading exporter of high-tech products in Latin America, accounting for the largest share of manufactured exports in the region.

(*Continued*)

Table 1
(*Continued*)

Characterization of Costa Rica's Medical Device Cluster	Description
Productivity	In the initial three-month period of 2023, it constituted 41% of the total exports from Costa Rica. This indicates an increase in productivity, with a 61% growth in the average production per employee since 1999. The company achieved 100% business continuity, with no interruptions during the global pandemic. Additionally, it gained access to a market of 2.8 billion people, representing 67% of the world's gross domestic product.
Job	It is anticipated that 30,000 positions will be created in the medical device sector by 2019. It is estimated that 98% of the top executives of companies in the medical device sector are of Costa Rican nationality. [10]
Environmentally sustainable practices	It is estimated that approximately 99% of the electrical grid is derived from renewable energy sources. Our organization has multiple facilities that have been certified under the Leadership in Energy and Environmental Design (LEED) or the EDGE green building certification programs.

countries to participate in global production networks and attract foreign direct investment flows.

To establish an analysis of trends in the field of life sciences, the documentary review technique was employed. In the development and application of the data collection instrument, a quantitative research methodology was selected for its suitability to the task. However, at the same time as the variables were established, qualitative research techniques were also developed. Accordingly, the research method employed was a mixed approach, which permitted the establishment of diverse perspectives on the object of study in order to obtain projections.

5. Discussion

According to Castro and Rojas [11], if a local study exists, it should be consulted to align the forecasting with the national reality. To forecast Costa Rica's future medical devices, they used the European Commission's Strategic Foresight methodology; it incorporates models for managing complex environments such as VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) and BANI (Brittle, Anxious, Non-linear, and Incomprehensible) frameworks. The analysis of identified megatrends involved assessing the industry's current state, recognizing challenges, and projecting potential scenarios for medical devices in 2050. See Table 2 [9].

Shabbir et al. [12] define that in today's competitive environment, organizations, in addition to trying to improve their production conditions, have a special focus on their supply chain component. In consideration of the potential growth and competitive landscape of the MD industry in Costa Rica, it is reasonable to anticipate a period of expansion and heightened competition. It is thus imperative to implement public policies designed to foster optimal conditions for innovation, considering the advancement of products and regulatory compliance, to foster high levels of reliability. According to Sorger et al. [13], big data is a core element of a fully digitalized value chain within the metal processing environment, with increasing digitalization among all involved stakeholders.

This is beneficial for both the public and private sectors. From the perspective of the public sector, it represents an attraction of investment and human capital development, as it represents a national productive development with possibilities for technology transfer and job development for Costa Rican citizens. From the perspective of the MD industry, it attracts industry to an area that offers a favorable environment for investment, with exceptional security and stability, as well as strong protection of intellectual property rights.

Table 2
Megatrends analysis

Classification of the megatrend	Megatrend selected	Variables	Indicators	The 2050 scenario
Digital	Artificial intelligence in manufacturing	Implementation of mechatronic knowledge (automation and robotics)	Automation and robotics of MD	MD manufacturing companies have incorporated and integrated around 90% mechatronics and automation elements into their production processes.
Physical	Innovation and management of new businesses to development and research	Product and process innovation	Several companies in Costa Rica have innovation strategies to develop human talent for the industry.	Half of the MD companies in Costa Rica have human and financial resources to improve the cluster and the new businesses.

(*Continued*)

Table 2
(*Continued*)

Classification of the megatrend	Megatrend selected	Variables	Indicators	The 2050 scenario
Digital	Value chain or healthcare blockchain	Development of interoperable big data systems between health centers	The proportion of Costa Rican firms building blockchain-based healthcare systems	In the year 2050, around 20% of the MD cluster will have developed Blockchain solutions for healthcare systems.
Physical	A modern legal framework	Approval of a legal system specialized in MD	Number of new laws that regulate the MD industry in Costa Rica	The Costa Rica cluster will have the technical and legal standards applicable to their industry and the products offered.
Biological	Preventive diagnostics	Development of Medical Devices and Tools for Preventive Diagnostics and Telemedicine	Number of medical devices and tools developed for the purpose of conducting preventive diagnostics and for use in telemedicine	An increase of at least 20% compared to 2023 in the number of medical devices and tools manufactured in Costa Rica that support preventive diagnostics and telemedicine is quantified.
Physical	MD Cluster	Costa Rica-based companies with local supplier ecosystems	Number of MD companies establishing supplier ecosystem with local Costa Rican companies	Increasing the capabilities of the supplier ecosystem for MD companies based in Costa Rica.

The main objective of this analysis is to identify the global megatrends that will define the future of the medical device sector and evaluate Costa Rica's position regarding them. At the same time, they seek to identify the critical factors that will determine their competitive capacity in the long term, with a view to the year 2050.

Chen et al. [14] determine the increase of uncertainty in the external environment, such as natural disasters, political impact, or major public health events, or the increase of uncertainty in the internal environment. Understanding allows us to carry out a rigorous analysis of the actions to be developed or analyzed within companies.

In their study, Lasa [15] argues that to remain competitive, companies must adapt their production systems to align with market demands. VSM is a technique developed by the Lean Production movement and oriented toward the redesign of production systems.

The current production systems within the medical industry are characterized by intense competition and high demands, as the requirements for product deliveries and the pursuit of increased profit margins benefit the organization. Lasa [15] identified a lack of in-depth analysis exploring the applicability of the technique in productive environments with disconnected flow lines. This study aims to evaluate the applicability of VSM in such business environments. The VSM process involves the following critical and fundamental points for its elaboration (see Figure 3).

The creation of a "VSM" necessitates the utilization of an array of analytical and developmental instruments, including:

1) Cycle times and lead times
2) Flow diagrams
3) Root cause analysis (Ishikawa, 5 whys)
4) Kaizen and continuous improvement events

Each of the companies that make up the medical device cluster performs a value chain analysis, which is sought depending on the business strategy and the market to be competed for. Within a standard flow, the medical device companies perform evaluations in relation to the following topics:

1) Delivery time – Suppliers
2) Delivery time - Export and import
3) Process cycle time
4) Product demand – Client

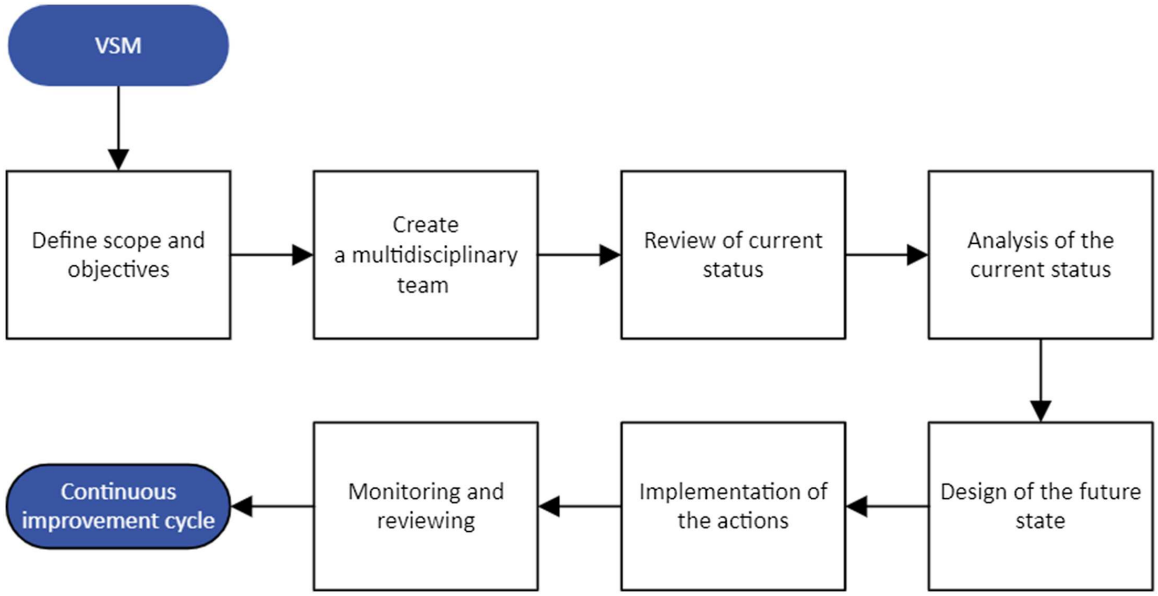
Considering the aforementioned information, the continuous improvement managers initiate the process of identifying the company's value chain and determining potential improvements within the manufacturing and organizational processes. It is essential to conduct continuous analysis of organizational and productive processes in order to maintain optimal competitiveness and facilitate business growth. As previously outlined, the pivotal aspect within the context of medical device companies is the logistics between raw materials and the final product, in addition to the manufacturing capacity of medical devices.

The establishment of the value chain is a critical and important factor for the management of businesses and the formulation of commercial strategic visions. However, companies currently lack the knowledge required to assess the maturity level of their value chains.

Jacquez-Hernández and López Torre [16] point out that existing models are diverse, with variations stemming from the included variables and their application scope. They emphasize the absence of a comprehensive measurement of the variables that constitute the value chain. The integration of local value chains becomes a key strategy for maintaining leadership in the provision of effective and safe healthcare, critically supporting and advancing the industry.

Huusko et al. [17] emphasize that the production of these devices requires meticulous assembly processes and stringent quality controls to meet international standards and ensure product

Figure 3
VSM development



efficacy. To achieve the above, SUPPLY CHANGE states that the healthcare sector's supply chain can significantly benefit from advanced technologies such as the Internet of Things, artificial intelligence, and blockchain. These technologies enhance the efficiency, transparency, and traceability of processes. Strategic collaboration among hospitals, suppliers, manufacturers, and distributors is essential for optimizing inventory management and mitigating supply shortages. Furthermore, diversifying supply sources is crucial to reducing disruption risks and developing predictive models that anticipate future needs, thereby improving inventory planning and establishing sustainable business practices with the environment.

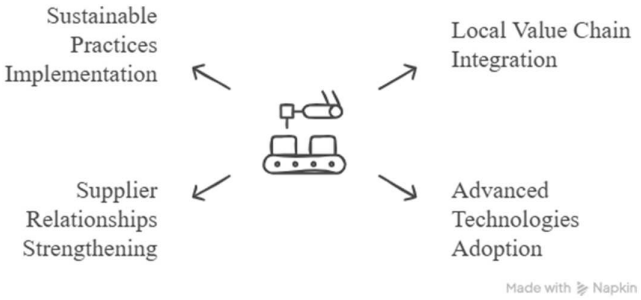
The adoption of sustainable practices not only benefits the environment but also helps reduce costs and improve the public image of healthcare organizations, with Costa Rica serving as an ideal location for such initiatives. These strategies are vital for achieving operational excellence and emphasize the importance of continuous adaptation and dedication to improving the supply chain.

Supply chain operations are susceptible to various uncertainties such as supplier disruptions or delays. Cui et al. [18] explain that to enhance the efficiency of supplier allocation and distribution, it is essential to ensure an optimal number of suppliers while strategically assigning regular shipment services across different levels. Additionally, the approach incorporates expedited transport solutions to streamline the connection between suppliers and terminal facilities, along with optimizing base-stock inventory levels to maintain a stable supply chain.

Additionally, in a country like Costa Rica, where the medical device sector has shown significant growth, establishing a robust local value chain is crucial. Developing a value chain contributes to the economy through job creation and ensures greater speed and efficiency in meeting both local and international market needs. Therefore, integrating a value chain in medical devices in Costa Rica is fundamental to sustaining the sector's growth and global competitiveness. See Figure 4.

Considering these points, companies must undertake a critical and mature analysis of their operational dimensions. As Jacquez-Hernández and López Torre [16] suggest, contemporary corporations will not define the industry's expectations nor

Figure 4
Strategic approaches in the medical device sector



represent its pinnacle. Instead, the focus should be grounded in the reality of the company's specific context.

The labor market in Costa Rica has been significantly influenced by the expansion of the medical industry, which has ushered in a new era of labor and given rise to a novel commercial and strategic vision for the country. This figure represents over 47% of the gross domestic product.

The environment linked to the analyzed industry presents a strengthening of the medical devices sector. In response to the new technical requirements for engineering professionals, universities and the government initiated an economic strengthening strategy for the country, as outlined in the Central American Institute of Public Administration [19]. Efforts are being made to enhance the country's competitiveness, human capital, and business environment for companies that choose to expand their operations in Costa Rica. See Figure 5.

Considering the data, an opinion survey was conducted among individuals currently employed in the medical device sector in Costa Rica, and Zhang et al. [20] determined that resources flow as logistics, information flow, and cash flow. The survey consisted of five questions and yielded the following results. See Table 3.

Concurrently, the MD sector deems it imperative to fortify the competencies requisite for employment within the sector. López

Figure 5
Survey results

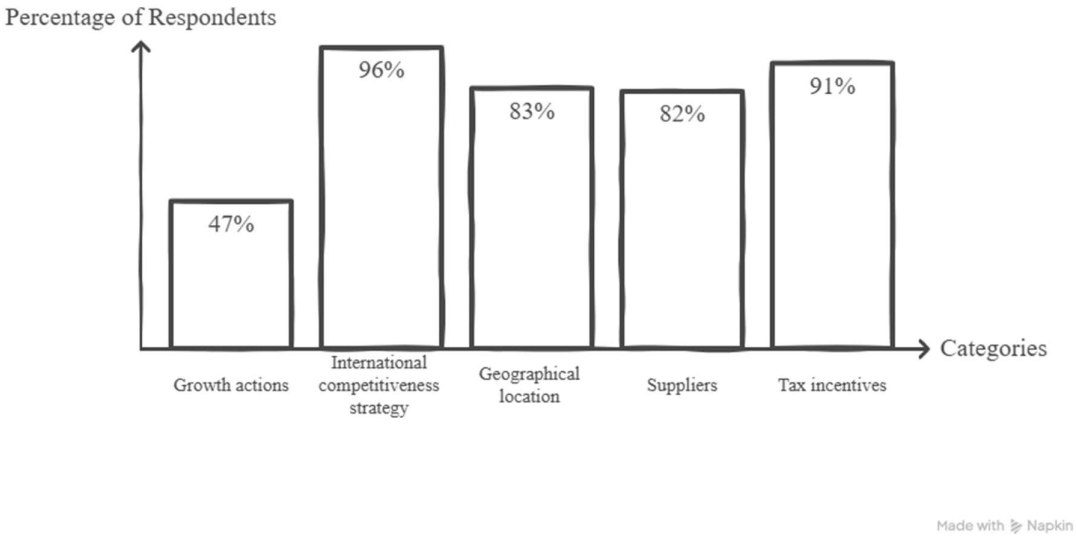


Table 3
Analysis and results of the categories consulted with workers in the MD sector in Costa Rica

Category analyzed	Result achieved
Growth actions	The results of the survey indicate that in order for Costa Rica to sustain its current rate of annual growth, it must implement measures to attract talent (47%) and to create economic policies (31%).
International competitiveness strategy	The vast majority (96%) of those surveyed highlighted the necessity for the formulation of an international competitiveness strategy for the medical device industry. Such a strategy could facilitate a comprehensive review of Costa Rica's value chain, enabling the implementation of the requisite adjustments to establish Costa Rica as the preeminent medical device manufacturing country in the region.
Geographical location	The survey revealed that 83% of respondents perceived the concentration of the MD cluster in Costa Rica to be primarily situated within the country's major metropolitan areas.
Suppliers	82% of the respondents stated that MD industries in Costa Rica do not use local suppliers. Based on the results obtained, future lines of research can be established, such as answering the following questions: Why are Costa Rican medical device companies not hiring local suppliers? Or, what does a company need to be a supplier to the medical industry in Costa Rica?
Tax incentives	The Costa Rican government has implemented a system of tax incentives for medical device companies, commencing with the exoneration of the Free Trade Zone regime. The majority of respondents (91%) indicated that they believe Costa Rica offers tax incentives. The tax incentives include Executive Decree No. 42334 S-COMEX-MCSP. Through the creation of the medical devices cluster, the decree in question establishes a collaborative framework that seeks to stimulate research and innovation and attract investments to strengthen the value chain and position Costa Rica as a regional hub in the sector.

asserts, "The contemporary milieu has undergone a transformation, and enterprises are now demanding highly proficient personnel, endowed with a command of the English language or other languages, and capable of functioning effectively in teams, while also demonstrating adaptability and conflict resolution abilities."

Sudirjo [21] determines that the global market offers great opportunities for companies to achieve growth and success at the National and International Level (KPIs). As stated by CINDE, it is both opportune and necessary to establish a multi-sector convergence of knowledge. This approach allows for the combination of capacities, technology, and investment in the MD sector, thereby maintaining Costa Rica's competitiveness in international trade within the life sciences sector. Consequently, training strategies are devised to maintain the MD cluster in the international market on a robust and permanent basis over time and to position the sector as the most competitive in terms of exports of goods and services.

These findings emphasize crucial elements such as growth actions, international competitiveness strategies, geographical localization, supplier management, and fiscal incentives. The narrative of the data is explicit and descriptive, centered on the evidence gathered from the survey and specialized academic literature.

We have included Table 3, which effectively summarizes the main discoveries from the survey. This table details the categories analyzed along with the corresponding results, which simplifies the understanding of the key points to achieve an appropriate linkage between the responses to the research questions and the exposed findings. Each of the results presented explicitly aligns with the

Figure 6
Determinants of industrial expansion

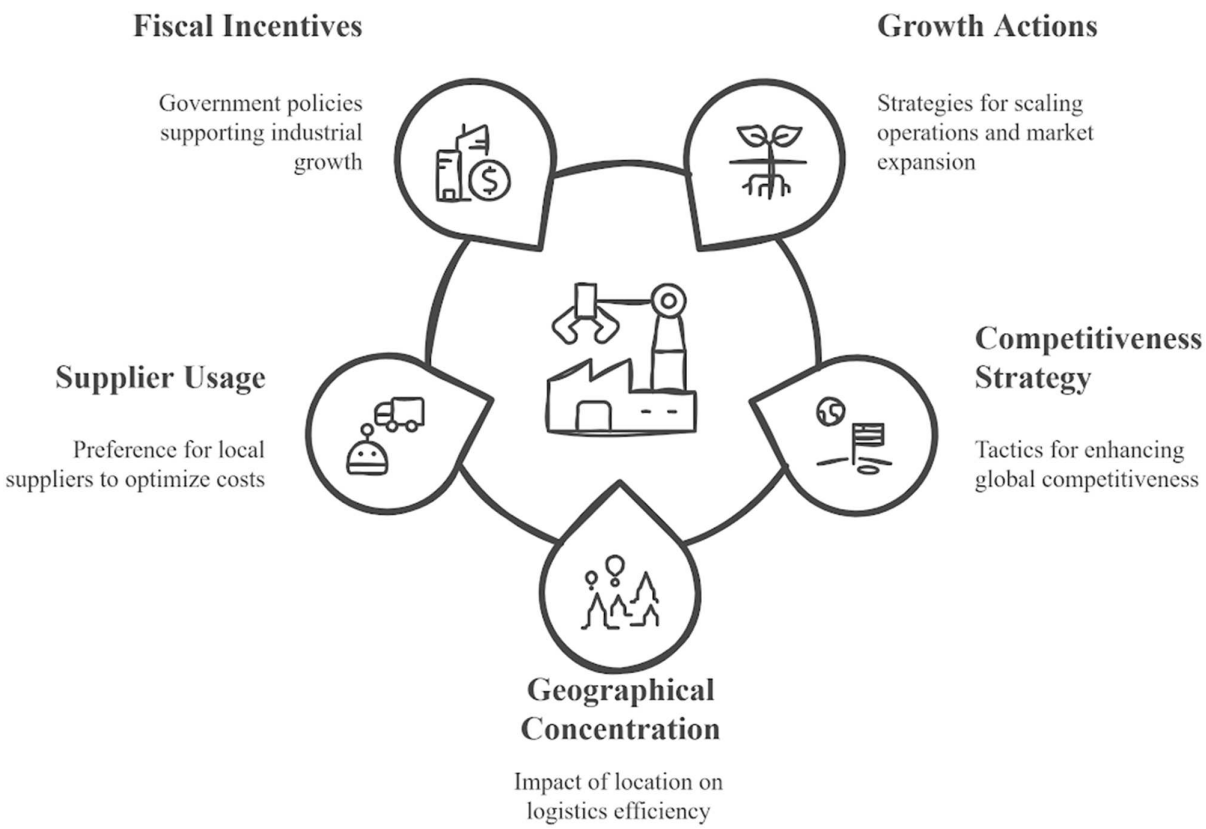
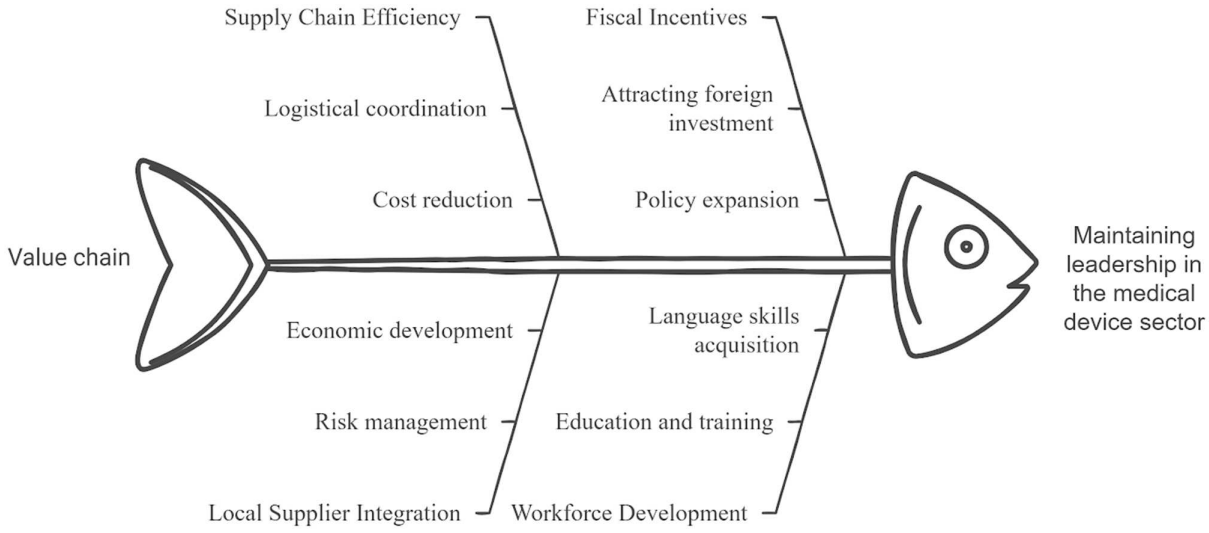


Figure 7
Boosting competitiveness in Costa Rica's medical device industry



investigative objectives of the study. Hereinafter, it is shown how each finding specifically responds to the research questions or hypotheses posed:

Growth actions: These results are essential for discerning the strategies implemented by companies in the sector to scale operations and expand their market share. It is evident that innovation and adaptability are essential pillars for sustained growth.

International competitiveness strategy: The data reveal how corporations are adopting tactics to enhance their competitiveness on a global scale, corroborating the hypothesis that adherence to international standards and investment in emerging technology are crucial for competitiveness.

Geographical concentration: This result explores the impact of geographical location on operational efficacy, indicating that concentrations in metropolitan areas optimize logistics and supply chain management.

Supplier usage: The findings regarding the preference for local suppliers over international ones clarify how companies

optimize their supply chains to foster sustainability and minimize costs, aligning with the strategic objectives of the study.

Fiscal incentives: The analysis of how fiscal incentives are supporting the sector's expansion highlights the importance of proactive government policies for industrial growth. See Figure 6.

This section establishes a clear framework for understanding how the research findings can be applied in the development of competitive strategies and in promoting improvements in the value chain of the Costa Rican medical device industry. Therefore, the results not only reflect the current situation but also propose specific strategic interventions for the future advancement of the medical device sector in Costa Rica.

6. Conclusions and Recommendations

To provide a forward-looking perspective based on the findings of this study, the following are highlighted as key conclusions to enable Costa Rica to not only remain competitive in the medical device industry but also to implement innovation, research, and sustainability through local value chains.

The medical device industry in Costa Rica has achieved sustained growth through continuous innovation and adaptability to global market dynamics. The ability to respond quickly to emerging trends and to adapt to international regulations has been crucial, demonstrating the sector's maturity in integrating new technological developments and advanced management approaches. To maintain local leadership, improvements to the sector's supply chain are necessary.

Costa Rica's strategic location, with its concentration of operations in metropolitan areas, has been vital for supply chain efficiency. This setup has allowed for better logistical coordination, cost reduction, and shorter delivery times, directly benefiting the international competitiveness of the sector.

Although dependence on international suppliers remains high, there is a significant opportunity to enhance the sustainability and resilience of the value chain through greater integration of local suppliers. This could translate into improved risk management and a greater contribution to local economic development. For this, social investment in education and the professionalization of the country's inhabitants, acquiring a second language such as English, are essential to incorporate local suppliers to meet the demands of the medical device industry.

Fiscal incentives have been fundamental in attracting and maintaining direct foreign investments; however, findings suggest that expanding and strengthening these policies could provide the additional boost needed to attract higher caliber technological and research investments, as well as the scientific development (R&D) necessary for the MD industry.

Based on the findings and results obtained, the research group, in accordance with national development objectives, makes the following recommendations, which could be applied to the Costa Rican medical device industry to sustain innovation and job creation in the country using local supply chains. See Figure 7.

It is recommended to implement a systematic approach for the continuous evaluation of the value chain, using techniques such as VSM to identify and eliminate inefficiencies. The adoption of advanced technologies, such as automation and robotics, should be a priority to maintain competitiveness in the global market and improve the professional upgrading required by the MD sector's labor force to foster innovation.

It is crucial to strengthen local capabilities by investing in technical training programs and professional updating, collaborating closely with academic institutions. This should include the creation of centers of excellence in emerging technologies, which would not only improve the quality of available talent but also foster local innovation to meet global quality standards.

Government policies should be reviewed and adjusted to offer specific incentives that promote R&D and the adoption of advanced technologies in the sector. This could include tax benefits for companies investing in the research and development of new products.

Encourage the creation of strategic alliances between private sector companies, universities, research centers, and the Costa Rican state (Triple Helix) to enhance the sector's innovation capacity. These collaborations could accelerate the development of new medical solutions and strengthen Costa Rica's position as a leader in the medical device market.

It is recommended to implement specific policies and strategies that promote the decentralization of medical device industry activities to regions outside the Greater Metropolitan Area. This could be achieved through tax incentives and grants for companies that choose to establish operations in rural or less developed areas. Moreover, the government, in collaboration with the private sector, should invest in the necessary infrastructure to facilitate this regional talent process, reducing congestion and pressure on services in metropolitan areas. This would also stimulate economic development in peripheral regions, offering new employment opportunities and promoting a more equitable distribution of economic resources in alliance with national goals for inclusive and sustainable development, thus maximizing the socioeconomic impact of the medical device industry across the Costa Rican territory.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data are available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Johan Rojas: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Karen Carranza:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization. **María de los Ángeles Campos:** Conceptualization, Methodology, Investigation, Resources, Writing – original draft.

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