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A proposal for a National Innovation System supported by the Value Chain of the Cuban Biotechnological Industry

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Abstract

A National Innovation System (NIS) supposes updated, continuous, and collaborative work between different agents, so the value chain approach fits perfectly with this NIS conception. The sector selected to illustrate our proposal is the biotechnological industry because of its structure in technology-based companies and its contributions to de Cuban GDP. This is the first research that works in a proposition of NIS for Cuba. The objective of this paper is to suggest a NIS for Cuba based on the value chain of its biotechnological industry. We follow a benchmarking methodology. First, we analyze nine international NIS experiences from developed and developing countries. Then, we highlight several items to be applied to the Cuban proposed NIS by analyzing five indicators: regulations, technology and innovation policies, financial systems, business activities, and research and education systems. The proposed NIS shows links between funding, production, service, and scientific sectors based on the biotechnological industry. It is considered beneficial for the three most important actors in a nation (companies, government, and society) because it allows a profitable and durable solution for economic and social troubles.

Keywords: Biotechnology; Cuba; National Innovation System; Value Chain

Introduction

The 90s witnessed the birth of a large body of research on the interrelationships of the companies' level of exploration and exploitation of knowledge and external knowledge providers, with the critical role of governments and policy in shaping these dynamics. In this way, the National Innovation System (NIS further on) concept becomes a popular analytical tool for researchers who want to get a firmer grasp of what determines the performance of such interaction. However, adopting the innovation system approach to developing countries is a relatively recent phenomenon (Fagerberg & Srholec, 2008; Pietrobelli & Rabellotti, 2011)

In developing countries like Cuba, building dynamic and innovative interactions between business actors, knowledge and technology providers, and the government is crucial to improve local businesses' ability to deal with the risk in their market operations. A NIS conception linked to the value chains generated by the business system stimulates efficiency, resilience, and business responsiveness according to society's requirements.

In Cuba, the State places in the foreground the role of science, technology, and innovation in all instances. Nowadays, links between all the activities or sectors are fuzzy. Likewise, national policies promote the development and sustainability of the biotechnological industry, given its nature as a producer of goods and services with high added value, ensuring its interaction with the rest of the academic, productive, technological, service sectors, etc. (PCC, 2019). According to these priorities for the Cuban government and given the lack of a global managerial tool to improve business and social benefits, our research question is: how could improve Cuban society and economy with the innovation as a driven?

In this research, we want to offer ideas for a NIS based on the value chain of the Cuban Biotechnological Industry (CBI). We choose CBI because it is the industry with the most Technology-Based Companies (TBC) in Cuba. Its contributions to GDP approximately represented 10% in 2019, being the industry with the highest contribution according to the Spain Secretary of State and Commerce (2021).

This paper is divided into five sections to achieve our main objective. Section one discusses the concept of innovation, NIS, and the value chain approach; also, in this section, we offer some general characteristics of the biotechnological companies. In section two, we explain the followed research method. Section three summarizes the common points of nine NIS studied, and then we present our proposal of NIS for Cuba, based on the value chain of the CBI. In section four, we explain all components of our proposal for the Cuban NIS. The conclusion section summarizes the benefits of our proposal for Cuban industry and society.

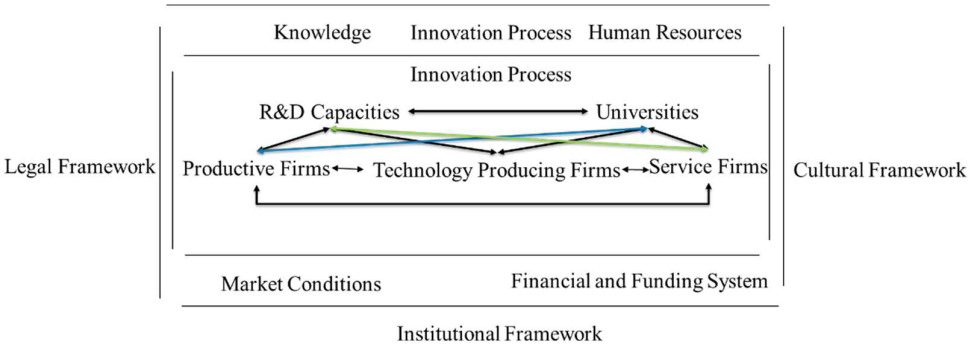
Brief theoretical framework

According to Schumpeter (1961), innovation means introducing new products, processes, organizational changes, etc., in an ongoing way oriented to the user. It is a process that starts with a new opportunity to achieve the invention's commercial success through designing, production, and marketing activities (OECD, 2010). Rodríguez & Núñez (2021) remark that innovation is more than technology and the market; it results from interactive processes in which companies use their own and others' resources through cooperation and coordination with other environmental actors. Open innovation, allowing internal and external knowledge flows, is promoted to extract the most outstanding value from the innovative potential, with a clear human nature component (Chesbrough, 2006).

Networks of actors in public and private sectors, whose activities and interactions initiate, import, modify, and disseminate new technologies and knowledge inside the borders of a nation-state, compose a NIS (Lundvall, 1992). According to Balzat & Hanusch (2004), a NIS also encompasses research and development efforts by companies and public actors (non-linear and multidisciplinary innovation processes) and innovation issues such as learning processes, incentive mechanisms, and availability of skilled labor. These authors affirm that NIS theory has been studied from a policy-oriented (benchmarking to reveal technology policy implications, innovation policy designs, incentive mechanisms for innovative action, etc.) and research-driven (descriptive frameworks and analytical models) points of view.

A NIS model has a variety of units of analysis (Balzat & Hanusch, 2004; Castro & Fernández, 2001; Kurpayanidi, 2021; Samara et al., 2012; Watkins et al., 2014) shown in figure 1.

Figure 1. A generic structure of a NIS model.



Source. Self made.

Figure 1 shows the main actors in a NIS: Governments, regulatory agencies, funding institutions, firms (which generate commercial innovations), and universities. In a continuous and open innovation process, these agents interact under determinate market conditions and in a specific institutional, cultural, and legal environment. Those links become a competitive advantage if innovative product creation and development are based on a value chain perspective (Mollenhauer & Hormazábal, 2012; Pietrobelli & Rabellotti, 2011). Information flows from an agent to another as a data-driven innovation systems (Yu et al., 2022).

On the other hand, a value chain identifies the strategic activities that provide a competitive advantage for the company and other activities that support the previous ones (Porter, 1985). Kaplinsky & Morris (2000) note that the value chain describes those actions required to carry out a product or service from its conception, through the intermediate phases of production, until its delivery to the final consumers. Pietrobelli & Rabellotti (2011) suggest that a value chain evaluates how companies and producers can interact and modernize while participating in these chains, positively affecting the development of companies, regions, and countries. The nature of the value chain approach is systemic and comprehensive, with the ability to generate valuable sources of information for decision-making processes regarding industrial policy, value aggregation, and intersectoral and territorial linkages aimed at reducing social and territorial asymmetries (Padilla, 2014; Yin et al., 2021).

We can say that both NIS and value chain are complementary approaches that benefit from each other. Padilla & Oddone (2016) point out that the functioning of NIS and the availability of infrastructure are factors to consider for scaling up to global value chains. García et al. (2018) note that the value chain approach becomes a crucial tool to model and analyze

the needed interactions between companies, governments, communities, and other actors to ensure adequate production and distribution of goods, services, and knowledge.

In this context, one of the most innovative industries is the biotechnological industry (Uecke, 2012). OECD (2010) defines biotechnology as applying science and technology to alive organisms and parts to produce goods, services, and knowledge. It is possible to characterize the biotechnology industry in terms of the units providing it value-added, which Link & Siegel (2007) summarize in three: universities and research institutes, biotechnology companies, and commercializing companies. Biotechnology applications can be found in various sectors, such as the healthcare sector (so-called red biotechnology or medical biotechnology). The main areas of application of red biotechnology are therapeutics, diagnostics, and pharmacogenetics (Uecke, 2012). It is usual in this industry to find TBC, which are independently owned entities based on exploiting an invention or technological innovation involving the assumption of substantial risks (Little, 1991; Peces Prieto & Trillo Holgado, 2019).

As an emerging science-based industry, biotechnology makes new demands on the institutional environment of a NIS (Cornelissen et al., 2021; Kaiser & Prange, 2004). The production of innovative products demands cooperation and coordination between universities and firms. It is because of the high and increasing cost of those activities, the meaning of interdisciplinarity, the closer relationship between basic research and industrial application, and between producers and customers of innovations. Therefore, those industries require new institutional arrangements, alliances, etc., for funding innovations, technology transfer, and the coordination of R&D activities. The correct interaction between the industry, value chains, and a NIS becomes significant to allow the growth of the biotechnological sector and its spill effect on the national economy and society.

Method

We develop qualitative research. This paper follows the benchmarking method. Hassan et al. (2022) consider three dimensions of benchmarking: (1) identification of international practices, (2) comparison, and (3) implementation and improvements.

After these steps, this paper identifies relevant NIS actors from developed and developing countries in the first place. The studied countries are Germany, US, Greece, Taiwan, Singapore, Brazil, India, Chile, and Costa Rica. We note that the concept of NIS was born in developed countries and was later applied to developing countries, a category in which Cuba is classified.

In step two, we extract some concurrences for the analysis in step one. Finally, these relevant results are extrapolated to our proposal of a NIS for Cuba.

Results

Step 1: Identification of international practices

Examining NIS in different countries, it's possible to affirm that their drivers are not the same in developed and developing countries. The notion of NIS has been developed from the background of advanced economies (Kayal, 2008). Then, according to Shulin (1999), the primary factor of NIS in developed countries is the ability to focus strategic management in companies to update their economic, social, and political matters.

Studying NIS in developed countries such as Germany, US, Greece, Taiwan, and Singapore, in contrast with experiences in developing countries such as Brazil, India, Chile, and Costa Rica, we can conclude that its conceptions have been developed around five indicators: reg-

ulations, technology and innovation policies, financial systems, business activities, and research and education systems. We highlight these five indicators once we explore the paper's content. The experts suggested some items that conform different NIS and we make clusters of items to reach the five general indicators.

Kaiser & Prange (2004) propose in Germany a multi-level approach, which directs the dynamic reconfiguration of NIS toward the sub-national and international levels. In contrast, Atkinson (2014) describes the broad elements of the NIS in US organized around the innovation success triangle: Business environment, regulatory environment, and innovation environment. Samara et al. (2012) analyze three subsystems and their independent variables for Greece, conducting six simulation experiments. In Taiwan, NIS supports the reverse value chain, and in Singapore, it emphasizes the government facilitation of technological learning from multi-national corporations (Kayal, 2008).

On the other hand, NIS in Brazil and India are studied by Nassif (2007). Brazil adopted a NIS in which three priorities for public policies were established: (i) Improvement and expansion of the infrastructure system; (ii) Increase in efficiency of the productive sectors, notably of tradeable goods; and (iii) Boost of the innovative capacity of firms with significant export orientation. In India, NIS is based on creating schemes to support the absorption of imported technologies by industry and develop, implement, and commercialize indigenous innovations. Its drives have been fiscal incentives for R&D and the development of medium and high technologies such as the pharmaceutical and information technology industries. Chile exposes the Design-driven Innovation System (DIS) through four elements: A model for innovation, actors, actions, and projects as good practices for innovation (Mollenhauer & Hormazábal, 2012). Finally, in Costa Rica, Herrera-González & Quesada (2013) proposed a value chain index. According to the Costa Rican NIS structure, the proposition identifies relevant value chain variables and innovation management in the metalworking sector.

Step 2: Comparison of international practices

According to regulations, a multilevel framework exists in the selected NIS to promote and evaluate the NIS performance. Technology and innovation policies aim to encourage and facilitate the improvement of innovations, but an access problem for the small and medium businesses keeps going, given their size and the volume of their activities. Related to the financial system, it prevails venture capital and the national funds for innovation activity. Business activities look for cooperation inside the company activities and other national or international firm activities in the value chain, aiming to create a product with social value. All these examined experiences recognize the significance of an efficient research and education system focused on the business demands, in which its international exposition must learn and develop the NIS.

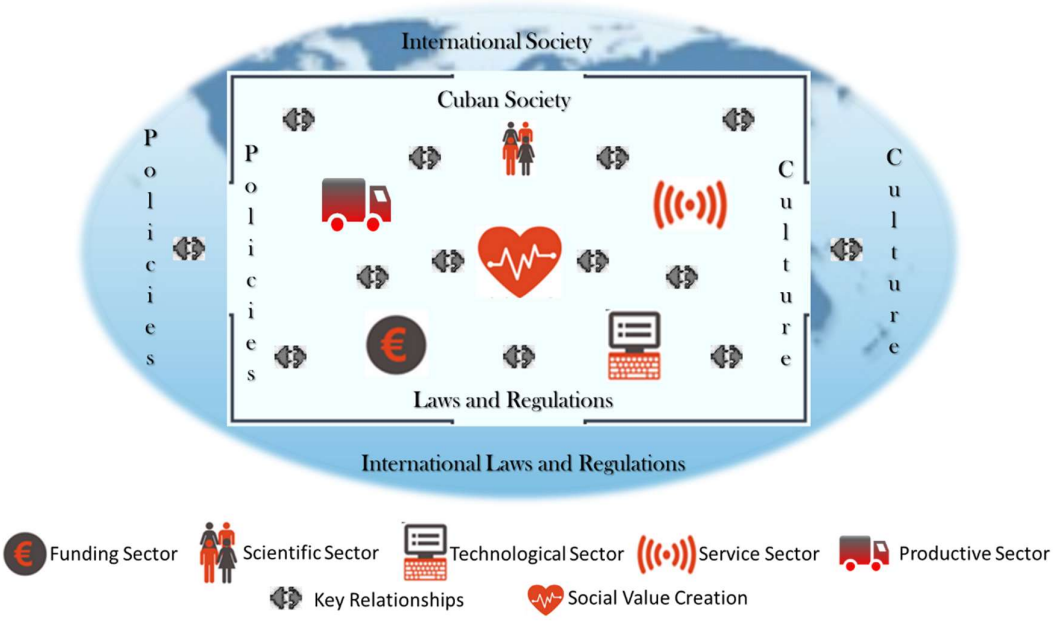
Studying four experiences of NIS in developing countries (Brazil, India, Chile, and Costa Rica), we conclude that the perception of Shulin (1999) persists. In developing countries: (1) NIS, understood as enhanced learning, is established for a specific development level and not for the desired level, (2) Links between organizations are weak and short-term, and (3) Promotion of innovative learning persists in a second place, while the search for investment is the main objective in policies and linkages. Identifying the lack or weak development of such improvement factors can be valuable to enhance innovation processes on a national level (Balzat & Hanusch, 2004).

Step 3: Implementation and improvements of international practices

For the Cuban government, innovation at the national and regional level is essential because of its benefits from an economic and social perspective. In this sense, in this paper, we offer ideas about a model of NIS for Cuba based on CBI. TBC forms this industry with a certain level of development within contributions to the national economy to capture foreign currency incomes.

Figure 2 shows the proposed NIS for Cuba. It includes the national and the international community in an open exchange under reliable and secure conditions. The driving of this NIS is the creation of value for Cuban society. Value creation comes to the CBI's current and future projects, products, or services. This industry demands highly qualified and productive workers, raw materials, services, advanced technology, and financial resources. These are the associations or alliances in the value chain, which are carried out by respecting norms, policies, and elements that form the national and international culture and idiosyncrasy.

Figure 2. NIS model based on the CBI.



Source. Self made.

Discussion

This section extrapolates the interactions between the indicators identified in the previous section (regulations, technology and innovation policies, financial systems, business activities, and research and education systems) to our proposition of NIS for Cuba.

Starting with the regulations, the State is present throughout the system, directing rules and laws. Government institutions such as the CITMA, BioCubaFarma OSDE, MINSAP, and MINDUS determine national policies in CBI and warranty the national framework for working in the value chain approach. Given that it is an open system, Cuban NIS must fulfill international regulations to produce and commercialize its products. So, a multilevel regulation framework is also present in the Cuban case. In this context, the interactions between national and international actors will be driven by the conception of the global value chain and by considering the governance characteristics in these chains.

According to technology and innovations policies, in 2020, the Cuban Minister Council recognized its existence in Cuba of TBC (Consejo de Ministros, 2020). Since this year, innovation and technology policies have been weakly established. We propose working on vertical policy coordination arrangements, regional innovation policies, and the promotion of R&D in biotechnology. In the value chain, these are relevant relationships that act as supporting activities and increase the margin and value for society.

The third indicator is the financial system. Cuban TBC have supported its activity with State contributions. Still, the current reality is different; the country's decision-makers have indicated its inability to fund all the projects that CBI develops. In turn, the profits generated by the centers and institutes of this sector are insufficient to support research and the production of medicines. In addition, this type of investment is not attractive for the domestic financial industry (national banks), given that they present an uncertain return (in the long term, they are high risk considered). The articulation of a NIS that contemplates relationships with the rest of the world should improve the current situation of the CBI. Usually, funding activities are classified as support activities in the value chain approach. We propose considering them as a primary activity because it is essential to maintain and extend CBI results. In this regard, internal changes will be necessary to improve. Additionally, a study is required to show the profitability of government contributions in each industry to eliminate inefficient businesses. Those funds can be redistributed to other initiatives that can capitalize on the investment and contribute to society. We also propose to create public or private financial entities whose money can come from the profits of different sectors (for example, the tourism sector) in the form of business angels, seed capital, or venture capital. International partners can offer varied funding options such as risk capital, joint ventures, subsidiaries, monetization of Cuban property, stock market, project financing, and international cooperation.

Business activities in the production sector must be developed under the conception of the value chain, working with the idea of insertion into global value chains. Links in the value chains must cover at least 80% of the inputs demanded by CBI: Transportation towards medicines productive centers or research centers, and, in the case of the final products, to the health centers and points of sale. In this way, the sustainability of a sector whose productions will always be in demand, a source of employment inside and outside the industry, and coverage of the National Health System (NHS) needs are guaranteed. CBI must create nationally and internationally demanded products, studying the already known ailments and identifying possible future conditions based on current conditions and their cure (disruptive innovation in global value chains). The novel products or projects must be accompanied by a correct presentation that includes their social value, the critical associations that this would imply, and their economic profitability. In addition, ensuring that innovation management in CBI companies should be more than a benchmarking exercise between companies is also a significant challenge.

About the research and education sector, it is vital because it guarantees the quality of the personnel that works in the CBI, which requires a high professional level. We propose the initial stages of R&D&I of the projects to be developed in the university laboratories or research centers, reducing costs and risks to the business sector. These are primary activities in value chain conception, indeed. In addition, we propose that Cuban universities offer academic programs in biotechnology and cooperation with international universities or knowledge providers. The global environment provides excellent and new practices that can and should be incorporated in the CBI, about qualified human capital willing to share knowledge and advanced technology that humanizes the processes and procedures and allows the realization of new and better activities more efficiently in most cases. Fostering the

interest of young people in this specific industry, and developing the necessary skills in them, is an element that guarantees the sector's sustainability, quality, and profitability. It also implies teaching them to innovate instead of replicating, which could be a pending task for the Cuban educational system.

Conclussions

Once we examined the common and disruptive points of the studied NIS, we conclude that the correct definition of the value chain integrating regulations, technology and innovation policies, financial systems, business activities, and research and education systems as key indicators; should bring social and economic benefits in the medium and long term.

Firstly, from a practical point of view, it contributes to the sustainability of an industry whose productions guarantee the subsistence of the NHS. Second, income generation from the industry will increase its contribution to the State budget, intended to cover or subsidize certain products, services, or social projects. Finally, advances will boost other sectors, such as agriculture, and the environment, giving stability to the Cuban economy.

Theoretically, the proposed NIS is oriented to the common good. It considers a collaborative process in which the different actors of society and the Cuban and foreign economies intervene. It implies progress because it is viewed as a sustainable solution. It means an effective transformation in social behaviors and practices at the micro, meso, and macro levels. It also offers the possibility of insertion of Cuban companies into global value chains.

We agree with Bartels et al. (2012) when they affirm that while the structural dynamics of knowledge management, decision-making, government-business relations, and the market are crucial to NIS behavior, overall innovation is dominated by market forces; which implies that developing economies should establish an institutional environment that supports needs and market transactions, supporting domestic NIS and economic growth, all that under the value chain approach.

The following step is to validate our Cuban NIS proposal by implementing it to confirm if the identified theoretic benefits are true in practice. The main limitation in this study consists of the delay between the Government approval and the existence of the necessary economic conditions to apply it, given the negative impacts of covid-19. Moreover, another limitation is the non-existence of a previous model of NIS for Cuba.

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