

# SCIENCE, TECHNOLOGY, AND INNOVATION POLICIES IN THE INTEGRATION PROCESS OF CENTRAL AMERICA AND THE DOMINICAN REPUBLIC: THE ROLE OF REPRESENTATIONS AND PERCEPTIONS

## *Las políticas de Ciencia, Tecnología e Innovación en el proceso de integración de Centroamérica y la República Dominicana: el papel de las representaciones y percepciones*

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### Abstract

This paper summarizes the findings of a qualitative study about the role of the representations and perception of Science, Technology, and Innovation Policies (STI) in the Central American integration process. It is based on interviews with policymakers and a parallel literature review process. The main finding points out the limitation of translating in practical terms the representations and perception of the positive role of STI policies in supporting the integration process and economic development at regional and national levels. An organic, long-term, and multiscale STI policy commitment is required to foster a more proactive and influential role of STI policy in the integration process and in supporting capacity building for innovation.

**Keywords:** integration; STI policy; mental models; STI representations; Central America; Dominican Republic.

### Resumen

Este artículo resume los hallazgos de un estudio cualitativo sobre el papel de las representaciones y la percepción de las Políticas de Ciencia, Tecnología e Innovación (CTI), en el proceso de integración centroamericana. Se basa en entrevistas con formuladores de políticas y en un proceso paralelo de revisión de literatura. El principal hallazgo señala la limitación de traducir en términos prácticos la percepción del papel positivo que las políticas de CTI pueden jugar en el proceso de integración y desarrollo económico, tanto a nivel regional como nacional. Se requiere un compromiso orgánico con las políticas de CTI de largo plazo y en distintos niveles para fomentar un papel más proactivo e influyente de tales políticas en el apoyo al desarrollo de capacidades para la innovación.

**Palabras clave:** integración; políticas de ciencia tecnología e innovación; modelos mentales; representaciones de la ciencia tecnología e innovación; Centroamérica; República Dominicana.



## Introduction

This paper aims to depict qualitatively the role of Science, Technology, and Innovation policies (STI) in the integration process of the relatively small and open economies of Central America (CA) and the Dominican Republic (DR) by considering the representations and perceptions of the role of STI policies held by policymakers and related stakeholders of STI policymaking process. Two institutional spaces directly related to the region's STI policies were considered in the analysis carried out in this paper: The Commission for the Scientific and Technological Development of Central America and Panama and the Central American System for Economic Integration (SIECA).

The above clarification is necessary because other regional critical spaces, such as the Central American Parliament or the Central American Higher Council for Higher Education, have indirectly participated in STI policies. Moreover, they have focused on issues such as capacity building, higher education management, academic exchange, accreditation, and standardization processes parallel to STI policies. Thus, this paper focuses on answering a research question: What has been the perception of the role of STI policy in the regional integration process of Central America and the Dominican Republic? It is based on a qualitative perspective related to a constructivist-related Ground Theory approach pointing out the data-gathering process consisting of field interviews with regional key informants supported by a literature review to develop an informed analysis of the STI perceptions of policymakers and business sector representatives (Thornberg, 2012; Urquhart, et al., 2010). Therefore, considering the grounded theory approach followed in this paper, the analysis of the interviews and their treatment as qualitative data constitutes a sufficient and valid source in methodological terms (Charmaz & Belgrave, 2012), which is indistinguishable from the number of interviews conducted.

As a result of the COVID-19 pandemic, Latin America and the Caribbean as a region (LAC) experienced a historical contraction of the Gross Domestic Product (GDP) of -6.8%, and at the level of CA countries, it was in the order of -7.3%, and the Dominican Republic -6.7% (CEPAL, 2021). The social and economic consequences of the pandemic will continue for the next few years, adding to the economic uncertainty in Europe due to the war in Ukraine.

The pandemic and its effects highlighted the national health and social security systems' weaknesses, destroying the modest progress in social protection accomplished over the last decade (CEPAL, 2022). In the same way, the pandemic brought up equally the limitations of infrastructures and scientific-technological capacities after years of a limited and highly restrictive commitment through science, technology and innovation policies that promoted productive development and the resilience of social and economic systems.

A review of the challenges of STI policies in Latin America and countries such as Spain and Portugal is found in the work of Alvarez et al. (2020). The paper explores the harmful effects that a pendulous and oscillatory STI policy has had due, among other factors, to the problems of agency and coordination and the institutional weakness in the field of STI that the pandemic exposed (Alvarez et al., 2020).

The social crisis has been more acute for most central American countries, small open developing economies with significant internal asymmetries despite the progress of the regional integration process. In terms of academic contribution, this paper hopes to visualize the interaction of mental models, representations, and economic rationales in STI policy in small-developing open economies and their importance in understanding the role of STI perceptions in complex economic dynamics.

Finally, this paper has a long history. It began with a series of interviews on STI policies in the

framework of the interactions with the Commission for the Scientific and Technological Development of Central America and Panama. Then, it evolved into an academic presentation made for the EU-SPRI Forum at Lund University in Sweden in 2016. The work was shelved until the COVID-19 pandemic in 2020 and 2021. Later, the initial ideas were recovered in the framework of a virtual regional seminar on STI policies and their role in the post-pandemic economic recovery in Latin America in the summer of 2021, organized by the Interdisciplinary Institute for Innovation of the University of Talca, Chile, and LALICS (the Latin American chapter of the Global Network for Economics of Learning, Innovation and Competence Building Systems).<sup>1</sup> Ultimately, this exercise aims to highlight the challenge of overcoming the representational barriers that limit STI policies to unleash their potential to support the development of the small open economies of Central America and the Dominican Republic.

### Understanding the Central America context

Although this paper focuses on the relatively small economies of CA and the DR, it is framed in the broader context of Latin American countries science and technology policy. In the Latin American and Caribbean context (LAC), STI policies have been a little complicated, despite recent efforts to increase the global investment in STI and research and development (R&D) in the last decades (Cimoli et al., 2005; Fariza, 2020; Grazzi et al., 2016).

At the beginning of the XXI century, in 2002, the global expenditure on R&D in LAC was 0.52% of the LAC Gross Domestic Product (or GDP). However, in 2011 it was 0.78% of the LAC gross domestic product (GDP), quite far from the expenditure of the European Union (1.95% of the GDP) and the United States (2.58% of the GDP), in the same year (RICYT, 2014). According to the same source,

in 2011, LAC countries accounted for 3.2% of the global R&D expenditure. Almost twenty years later, in the LAC region, the R&D expenditure remains under 1% of its GDP (Amorós et al., 2019).

Based on the Global Innovation Index (WIPO, 2021), Costa Rica is ranked as 56 most innovative economy in the world and the third in Latin America, behind Chile and México and ahead of major economies such as Argentina and Brazil, which makes the STI policy analysis a relevant issue at the Central American and Dominican context. It has implications in terms of strengthening the integration process of the small open economies of Central America and the DR. However, considering the adverse socioeconomic impact of the COVID-19 pandemic, STI policies should be rethought more comprehensively. In section 3.2, this comprehensive perspective is treated in more detail.

### Selected socioeconomic indicators

Eight selected socioeconomic indicators of CA countries and the DR, corresponding to several periods, are shown in Tables 1A and 1B (WB, 2022). Both tables show the impact of the pandemic on economic indicators, such as the impressive contraction of GDP, which in the case of Panama was -17.9%, followed by the collapse in Honduras (-9%), El Salvador (-8.6%) and the Dominican Republic (-6.7%).

<sup>1</sup> <https://institutodeinnovacion.otalca.cl/?p=2102>

**Table 1A**

*Socio-economic indicators of Central American countries, Panama, and the Dominican Republic*

<b>Country/Economy</b>	<b>2015</b>	<b>2019</b>	<b>2020</b>
<b>Costa Rica</b>			
Population	4,847,805	5,047,561	5,094,114
Population density	94.9	98.9	99.8
% Urban population	76.9	80.1	80.8
GDP per capita in PPP	17,090.8	22,511.3	22,132.5
% GDP growth annual	3.7	2.3	-4.1
National poverty line	23.6	23.9	30.0
GNI Index	48.4	48.2	49.3
R&D expends % GDP	0.45	N/A	N/A
<b>Dominican Republic</b>			
Population	10,281,675	10,738,957	10,847,904
Population density	212.8	222.3	224.5
% Urban population	78.6	81.8	82.5
GDP per capita in PPP	14,740.8	19,191.6	17,935.7
% GDP growth annual	6.9	5.1	-6.7
National poverty line	N/A	21.0	N/A
GNI Index	45.2	41.9	39.6
R&D expends % GDP	N/A	N/A	N/A
<b>El Salvador</b>			
Population	6,325,121	6,453,550	6,486,201
Population density	305.3	311.5	313.0
% Urban population	69.7	72.7	73.4
GDP per capita in PPP	7,597.7	9,147.3	8,420.5
% GDP growth annual	2.4	2.4	-8.6
National poverty line	N/A	N/A	26.2
GNI Index	40.6	38.8	N/A
R&D expends % GDP	0.14	N/A	N/A

*Note.* The source is World Bank (2022).

As can be seen in Tables 1A and 1B, four of the seven countries reported R&D expenditures as a fraction of GDP: Costa Rica, El Salvador, Guatemala, and Panama, but such reports except Costa Rica show a level of investment that, in some cases, is more anecdotal. In the latest available year (2015), Costa Rica reported a spending level of 0.45% of GDP, while El Salvador reported spending of 0.14% of GDP for the same period, the same as Panama,

for a 3 to 1 ratio of Costa Rica. Other CA countries that reported spending on R&D were Guatemala (0.03%) and Honduras (0.01%). It is important to note that the Dominican economy, the largest size of the seven economies, does not report spending on R&D. At the beginning of the eighties, in the apogee of the import substitution period, the DR accounted for R&D expenses of around 0.35% of the GDP (Alcorta & Peres, 1998, p. 865).

**Table 1B**

*Socio-economic indicators of Central American countries, Panama, and the Dominican Republic*

Country/Economy	2015	2019	2020
<b>Guatemala</b>			
Population	15,567,419	16,604,026	16,858,333
Population density	145.3	154.9	157.3
% Urban population	50.0	51.4	51.8
GDP per capita in PPP	8,194.4	9,019.3	8,853.7
% GDP growth annual	4.1	3.9	-1.5
National poverty line	N/A	N/A	N/A
GNI Index	N/A	N/A	N/A
R&D expends % GDP	0.03	N/A	N/A
<b>Honduras</b>			
Population	9,112,904	9,746,115	9,904,608
Population density	81.4	87.1	88.5
% Urban population	55.2	57.7	58.4
GDP per capita in PPP	4,823.4	5,978.8	5,420.2
% GDP growth annual	3.8	2.7	-9.0
National poverty line	51.5	48.0	N/A
GNI Index	49.2	48.2	N/A
R&D expends % GDP	0.01	N/A	N/A
<b>Nicaragua</b>			
Population	6,223,234	6,545,503	6,624,554
Population density	51.7	54.4	55.0
% Urban population	57.9	58.8	59.0
GDP per capita in PPP	5,293.9	5,682.2	5,569.7
% GDP growth annual	4.8	-3.7	-2.0
National poverty line	N/A	N/A	N/A
GNI Index	N/A	N/A	N/A
R&D expends % GDP	N/A	N/A	N/A
<b>Panama</b>			
Population	3,968,490	4,246,440	4,314,768
Population density	53.5	57.2	58.2
% Urban population	66.7	68.1	68.4
GDP per capita in PPP	25,319.2	32,769.9	26,782.5
% GDP growth annual	5.7	3.0	-17.9
National poverty line	23.0	21.5	N/A
GNI Index	50.8	49.8	N/A
R&D expends % GDP	0.12	N/A	N/A

*Note.* The source is World Bank (2022).

Eventually, and probably related to the structural first reform program of the mid-eighties (Espinal, 2001), which led the Dominican economy from an agro-industrial and commodity exports model to a

service one, the R&D expenses vanished. A casual reference accounts for a level of R&D spent around 0.03% of GDP in 2004 (SEESCYT, 2008). Even in cases where R&D spending is reported, efforts to

institutionalize both the measurement and persistence of R&D spending encounter cultural and political barriers that affect the ability to capture the effects in improving absorption capacity and innovation of R&D spending even in middle-income and developing economies (Griffith et al., 2003; Inekwe, 2015). It is the case of those Central American economies with higher relative levels of development, such as Costa Rica, Panama, and the DR.

COVID-19 creates a pronounced economic impact on the exposed economies of CA and the DR, especially in those with the highest sensitivity derived from previous structural imbalances, such as the cases of Honduras, El Salvador, and Nicaragua (CEPAL, 2022). Therefore, it is essential to point out that before the COVID-19 pandemic, the socio-economic differences between CA countries probably had their deep roots in the ideological conflict and aftermaths of the civil wars that shook Central America throughout the eighty's decade. During the conflict period, Costa Rica remained relatively untouched by the conflicts that made this region one of the most critical hotspots of the Cold War (Kincaid & Bulmer-Thomas, 2001). Some preliminary evidence suggests a catching-up process in progress after the integration process, but it was slower than expected (Barrientos Quiroga, 2010).

### **The Central America integration processes: an overview**

Central American countries are immersed in an ongoing economic and political integration process, which has had four historical stages that, to a great extent, have resulted from the political, economic, and ideological confrontation in the second half of the 20<sup>th</sup> century. These four stages embrace public policies designed to facilitate such an integration process.

- The Charter of San Salvador established the Organization of Central American States (ODECA) in October 1951. The outcome of the work of

the ODECA can be measured through the creation of the leading integration mechanisms such as the unification of educational programs, the unification of traffic signals, the Central America Multilateral Treaty of Free Trade and Economic Integration in 1958, the unification of customs, and the creation of the Central American Bank of Economic Integration in 1960.

- A period of calming down and political tension resulting from the ideological confrontation of the Cold War from the late sixties to the late eighty's decade led to civil wars in El Salvador, Guatemala and Nicaragua and dictatorships in Panama and Honduras.
- After the conflict, a third stage began creating the SICA system in October 1991, which started a new political and institutional framework. Among other accomplishments, this framework included the creation of the Central American Parliament, which began its operations in October 1991 because of the peace agreements signed in 1986 and 1987.
- In the first half of the first decade of the 21<sup>st</sup> century, the integration process continued, reinforced by free trade agreements signed conjointly with the Dominican Republic. The first was the DR-CAFTA, signed with the United States on August 05, 2004.<sup>2</sup> The second was the Commercial Partnership Agreement signed on June 29, 2012, with the European Union.

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<sup>2</sup> Seven countries are part of the DR-CAFTA: the United States of America as a significant partner, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, and Nicaragua. This free trade agreement (FTA) covered international trade markets of around US\$ 45 billion in 2007, being the third Latin American export market for the US and the 14<sup>th</sup> worldwide and representing a market of around 50 million consumers (U. S. Department of Commerce, 2014).

Several organizations and agencies are part of the SICA, such as the Secretariat for Economic Integration (SIECA) and the Commission for Scientific and Technological Development for Central America and Panama (CTCAP). After the conflicts and civil wars, there was a breakthrough in economic growth. However, some old problems persisted, such as significant inequalities in income distribution, the states' institutional weakness, and low law enforcement (Kincaid & Bulmer-Thomas, 2001).

### Conceptual framework

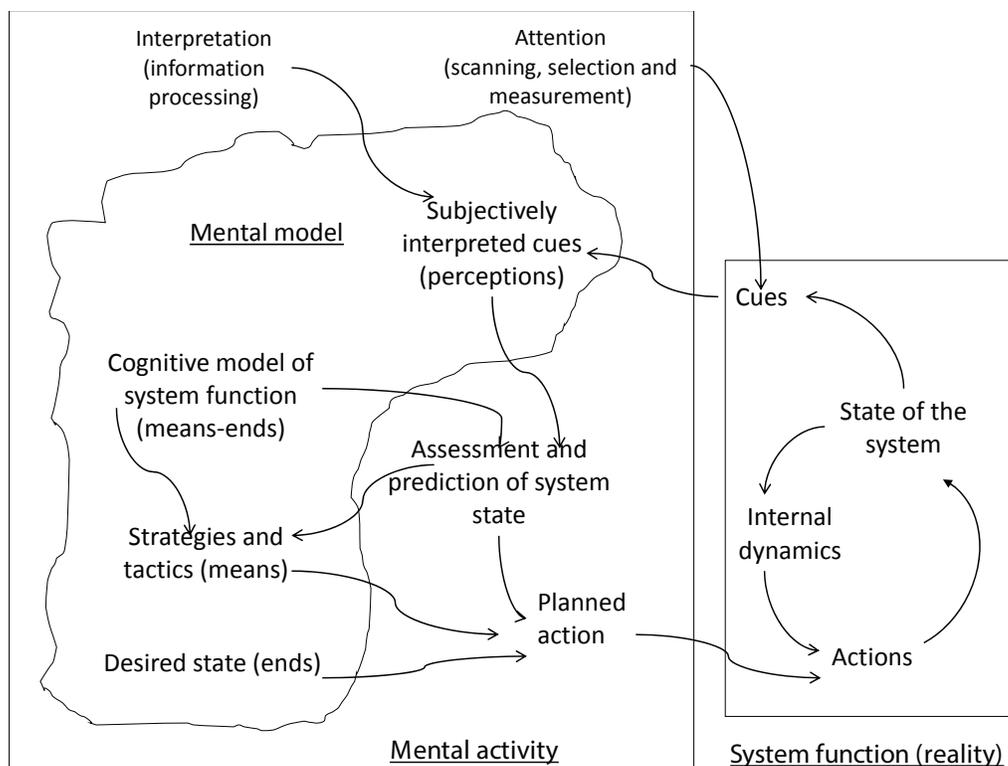
This paper's related grounded theory approach has two critical conceptual implications. The first is that the treatment as qualitative data of the interviews simultaneously confers the source and contextual reference status (Charmaz & Belgrave, 2018). It allows the analysis to acquire a heuristic value by itself; therefore, the theoretical interest shifts relationally to the most available sources of the field studied, in this case, STI policies. The second implication is more practical and consists in expanding the specific body of knowledge at the regional level on STI policies, adding a theoretical and methodological complementary to the most recent literature on STI policy analyses at the level of Central America and the Dominican Republic (Bonilla & Serafim, 2021; Casale & Buenrostro, 2014; Gómez-Valenzuela, 2020; Gómez-Valenzuela et al., 2020; Padilla-Pérez & Gaudin, 2014; Viales-Hurtado et al., 2021). Thus, this paper highlights one key aspect of STI policy analysis at the Central American level about the role of representations of STI policies in the economic integration process, considering the perspective of selected policymakers and related stakeholders. In the case of STI policies, mental models, representation, and rationales play a complex role in terms of economic justification in supporting policy design and implementation, affecting the effective incorporation of STI policy in developing and policymaking dynamics (Borrás & Edquist, 2013; Flanagan et al., 2010).

### Mental models and STI rationales

At this point, the distinction between mental models and STI policy rationale arises. According to North (1994), mental models are the internal representations that individual cognitive systems create to interpret the environment; institutions are the external (to the mind) mechanisms that individuals create to structure and order the world (Denzau & North, 1994; Mathieu et al., 2000). North's explanation of the MMs puts them as a structure or scheme that allows individuals to understand and interpret the mixed signals received by the senses (North, 1994). These mental models are categories that evolve through time due to learning experiences, continuous learning processes, exposure to new ideas and the consequent feedback deriving from them (Richardson et al., 1994). The internal representation of an external system could be defined as 'knowledge structures that allow individuals to interact with their environment (Mathieu et al., 2000). Thus, this approach entails that the 'belief system' and associated perceptions are frames that help predict specific system outputs based on some input parameters, lining up individuals and collective expectations.

According to some authors, it entails intentions, perceptions, system structures, and plans, which define a mental loop supporting decision-making processes (Richardson et al., 1994). The same authors identified three sub-models of mental models: end models, mean models, and mean/end models. The end models contain perceptions and information about what one tries to accomplish in a decision or stream over time. The mean models lead to a plan of action, and the mean/end models represent the stock-and-flow-feedback structure of a complex dynamic system or a chain of associations linking a policy level to an outcome (Richardson et al., 1994). The three sub-models interact in a mental loop, as shown in Figure 1.

**Figure 1**  
*Mental model loops*



*Note.* The source is Richardson et al. (1994).

Based on Figure 1, mental models define strategies, tactics and policies oriented to intended goals. The mean/end models are simple associations linking a policy to an outcome. Mental models are relevant cognitive structures in organizational and behavioral terms to explain how individuals or teams can cope with challenging and changing task conditions (Mathieu et al., 2000). The cognitive structures may operate as rationales or justifications, supporting decision-making. The rationale supporting a particular STI policy design in regional economic integration can play a decisive role in an STI policy's scope. For instance, a neoclassical rationale would eventually emphasize certain aspects, such as the processes of industrialization, technology transfer and R&D

subsidies. In contrast, a more systemic or evolutionary rationale would foster learning processes and cognitive capacity and avoid the lock-in process and other policy options (Laranja, 2008). STI policy rationales may range from a neoclassical perspective to an evolutionary/systemic perspective (Magro & Wilson, 2013).

The neoclassical perspective is based on the 'market failure' analysis, emphasizing the production of sub-optimal scientific and technical knowledge. The evolutionary perspective highlights the accumulative learning process and institutional performance (Fagerberg & Verspagen, 2009). At the same time, the STI policy rationale could be analyzed from a

more theoretical perspective covering several fields, such as the economics of innovation and technology concerning economic growth, the management of industrial innovation, organizations and innovation, and systems of innovation, among other academic perspectives (Martin, 2012). A taxonomy of different STI policy rationale includes the neoclassical approach (market-failure perspective on sub-optimal production of knowledge); the Schumpeterian growth theory (endogenous growth and innovation depending on learning process, R&D investment, and market-driven); the neo-Marshallian approach (emphasis on social, cultural and institutional setting at the regional level to foster growth), systemic institutional approaches (Technology and knowledge as a source of positive externalities depending on the institutional context); and the evolutionary perspective about technology as explicit and tacit knowledge (Laranja et al., 2008).

### STI policy in the region

The evolution of the LAC STI policies can be summarized before and after the structural reforms implemented in the late '80s and early '90s of the Twenty Century (Alcorta & Peres, 1998; Gómez-Valenzuela, 2020; Vonortas, 2002). The aftermath of the failure of protectionist policies between the '60s and the late '80s, known as the import substitution period, led to an aggressive period of industrialization through the public sector's intervention in most LAC countries. In the nineties, the structural reforms led to aggressive economic liberalization, deregulation, and privatization, leading to the emergence of two production patterns (Cimoli et al., 2009; Gómez-Valenzuela, 2020). The 'labor-intensive activities' such as tourist services and various types of free zone parks, mainly of textiles in the Central America and Caribbean area, and activities based on natural resources exploitation such as mining and metallurgy, together with a relatively strong industrial sector in the Southern Cone (Cimoli et al., 2005). At the end of the nineties of the twenty century, Alcorta and

Peres (1998, p. 877) found evidence of the differentiation production patterns and their effects in terms of technological specialization and innovations performance between Central America and the Caribbean and southern cone countries, reaching the latter a relative higher innovation performance (Bonilla & Serafim, 2021; Viales-Hurtado et al., 2021).

The wave of changes in STI policies was not homogeneous in all the LAC countries. In some countries, a more aggressive and dynamic private sector produced better results in human resources training, collaborative research networks and scientific infrastructure. It was the case in countries such as Argentina, Brazil, Chile, and Mexico, and to a lesser extent, Colombia, Costa Rica, and Uruguay. Nevertheless, LAC countries broadly shared many structural weaknesses associated with the prevalence of linear approaches in STI policy related to the influence of the neoclassical rationales and the perspective of systemic failures as structural aftermath of the liberalization period of the nineties (Gómez-Valenzuela, 2020; Padilla-Pérez & Gaudin, 2014).

Nowadays, the state of STI policies in the region follows two rhythms that seem not to be determined by the differentiated production patterns between Central America and the Caribbean and the Southern Cone but by the gap between the academic discourse and the political speech (Gabriela Dutrénit & Martin Puchet, 2017; Ordóñez-Matamoros et al., 2021). There has been a rapid move in favor of a mission-oriented policy approach with a solid transformative innovation policy focus on the academic discourse side. However, a more robust approach associated with linear innovation models still prevails on the public policy side (Ordóñez-Matamoros et al., 2021; Villa, et al., 2020).

In a mission-oriented or transformative innovation policy approach, STI policies are conceived from a more comprehensive perspective, focusing on pursuing

market transformations to make them more efficient and more committed to sustainability and inclusion (Kattel & Mazzucato, 2018). Mission-oriented politics and the broader perspective of transformative politics relate to the ideas of an entrepreneurial state, which pursues significant long-term changes in sociotechnical systems, including structures of production and consumption, to prevent threats to society (Mazzucato, 2016).

However, the truth is that the current global scenario characterized by the aftermath of the COVID-19 pandemic and by the conflict in Europe and the war in Ukraine undoubtedly requires a change in the direction of STI policies (Ordóñez-Matamoros et al., 2021). This change of trying to bet on more resilient and inclusive economic and social systems committed to a transition that harmonizes economic development with conservation is particularly crucial in Central America and the Caribbean, given their well-documented vulnerability to factors such as climate change (Bouroncle et al., 2017; Hsiang, 2010). It would allow overcoming the linear perspective of innovation processes, making R&D efforts, for example, focus on addressing the social and long-term challenges of the global conjuncture (Diercks et al., 2019; Švarc & Dabić, 2021).

## Methodology

The constructivist and related grounded theory approach can be defined as a contextual inquiry of a contextual type, which seeks to compose theoretical explanations of a medium ranging from a systematic review to data collection (Lawrence & Tar, 2013; Timmermans & Tavory, 2012). From the above perspective, data is much more elastic and flexible than one might think. It also includes qualitative information such as an interview, policy document, and a literature review, which can be deconstructed from its essential conceptual elements (Wolfswinkel et al., 2013). It is an important issue from a methodological point of view since it highlights the importance of treatment in qualitative data

from documentary information, including legal documents or interviews, regardless of their completion date (Charmaz & Belgrave, 2012; Charmaz & Belgrave, 2018; Wolfswinkel et al., 2013).

A sequential three-step approach was defined to cope with the research problem in the Introduction. The first step was to review the literature on the economic integration process of Central America and the Dominican Republic and the institutional context at the national and regional levels that underpins STI policies. The second step consisted of conducting semi-structured interviews with key actors at the regional and national levels in the field of STI policies to express the role that STI policies have played in the process of regional integration. This second methodological step has important implications from the point of view of the number of actors interviewed. The strategy followed is based on theoretical sampling, which consists of selecting participants considered experts in their field based on their training and experience. Thus, it is expected that better data will be provided for their analysis—qualitative treatment (Thomson, 2010).

The third step consisted of integrating the interviews into a structured set that served as the basis for the analytical process. This structured set constituted the data that was later analyzed with a qualitative approach based on the coding of the texts with the help of the MaxQDA software Ver 11. Table 2 presents information about the interviewees, including their institutional affiliation. Their identities are protected, and their names are in acronyms.

**Table 2**

*Key informants interviewed*

No.	Name	Position during the interview	Date	Place
1	LM	National Council of Private Enterprise (CONEP by its acronym in Spanish)	6-May-10	Santo Domingo, Dominican Republic
2	MC	Industrial Association of Santo Domingo (AIEH by its acronym in Spanish)	7-May-10	Santo Domingo, Dominican Republic
3	AVA	National Competitiveness Council (CNC by its acronym in Spanish)	11-May-10	Santo Domingo, Dominican Republic
4	JCG	Secretariat of Economic Integration of Central America (SIECA by its acronym in Spanish)	26-May-10	Guatemala City, Guatemala
5	RMA	National Secretariat of Science and Technology (SENACYT), Guatemala. Central American Commission of Science and Technology (CTCAP by its acronym in Spanish)	27-May-10	Guatemala City, Guatemala
6	HF	National Secretariat of Science and Technology (SENACYT)	27-May-10	Guatemala City, Guatemala
7	FG	Euromerican Program of Science and Technology (CYTED by its acronym in Spanish)	2-Jun-10	San José, Costa Rica
8	LAM	Ministry of Higher Education, Science and Technology of the Dominican Republic	4-Jun-10	Santo Domingo, Dominican Republic

Several formal and informal interviews were conducted between May and June 2010 in Costa Rica, Guatemala, and the Dominican Republic. An interview guide was developed and handed out in advance. The interviews were transcribed and then analyzed in an integrated way, approaching them as a bundle of data to explore the similarities and the related mental models.

**Results**

It is necessary to return to the research question posed in the Introduction: What has been the perception of the role of STI policy in the regional integration process, considering its representations by decision-makers in CA and the DR? Based on the analysis carried out in the frame of this research, a preliminary answer points out toward a fragmented role at policy level conditioned for

at least three intertwined perceptual layers: 1) the competing political space of a barely understood the role of STI policy in fostering development; 2) the relative low-level institutional development at the regional and national level of the national bodies of science and technology (ONCYT), and 3) an encapsulated rationality that looks at CTI policies and the related decision-making restricted to the scope of the national ONCYTS.

The first layer implies a limited domain of policy-making space where STI policies must compete at a disadvantage with other legitimate public policy interests, creating coordination failures at different stakeholders and decision-making mechanisms at national and regional levels. The coordination failures are well-known in the literature (Magro et al., 2014), but in the CA context, several competing policy concerns, such as citizen security or the fight against poverty in

the region, overshadow the potential contribution of STI policies to development needs creating, in some cases, high expectations but a lower level of policy and institutional commitment (Krishna, 2013). In some policymaking spaces such as the SIECA, it is recognized that social issues such as the prevalence of poverty, crime and insecurity are limiting factors of the Central America integration process:

[The primary constraint continues to be the structural characteristics of our countries in terms of poverty, legal uncertainty in many cases, and insecurity of goods and people (aspects such as drug trafficking, crime, arms trafficking, and related problems). In other words, security for investment is a crucial issue in ensuring the proper functionality of the investment in terms of profitability and guaranteeing some legal certainty.]. Interview with JCG, May 26, 2010

The preoccupation with poverty and security issues in CA countries has been one of the most relevant political concerns for almost two decades. A report on Human Development focused on security issues in Latin America and the Caribbean, elaborated by the United Nations Development Program (PNUD, 2013), highlighted the negative impact on human development, integration and growth of the high level of insecurity in countries such as Honduras, El Salvador, Guatemala and the Dominican Republic. It is an effect that can reduce the “cognitive horizon” concerning the STI policy and is detrimental to plans and strategies intended to promote at national or regional levels development based on capacity building and innovation (Kuhlmann et al., 2010).

The second layer considers the institutional context. The leading role of Costa Rica and Panama in STI is regionally recognized, which has been understood as the result of the relative availability of financial resources and institutional stability during the last 15 years. It also is related to the relatively higher public expenditure on education (Casale & Buenrostro, 2014; Padilla-Pérez & Gaudin, 2014). The institu-

tional development level supporting STI policy is a cornerstone in the CA and the DR context. Thus, STI institutional stability is crucial in developing a differential policy pattern in CA countries, and the existence of a legal frame that supports STI policy is considered an advantage:

[Other countries are much more advanced than Guatemala, such as Costa Rica and Panama. We lack financial resources, but we have our structure and law. Some other countries are delayed because they do not have their law defined.]. Interview with RMAL, May 27, 2010

At the national level, STI policy has been reduced to the policy of things, which means having a law, a public organization, or research funds. In other words, STI policy at the regional level has been treated as a general element without a structural relationship with the development policies at the regional level and as part of the integration process. The institutional imbalance and the asymmetric relations at

[In general, a great effort has been made. The advantage of Costa Rica is its continuity and institutional stability, including the existence of a ministry of science since 1990. In other countries, we are in this ongoing process. We have generally solved a structural issue to stabilize the S&T institutions and then think about issuing policies.]. Interview with FG, June 02, 2010

The most critical STI organization at the regional level is the CTCAP, which is part of the Central American Integration System (SICA). The CTCAP was formally constituted in 1976, in the frame of regional cooperation initiatives of the Organization of American States (OAS), during the period of import substitution. However, still, prevail a kind of low profile of CTCAP concerning the SICA setting:

[We depend on the SICA as such (the CTCAP belongs to the SICA) ... We have not yet achieved specific spaces within the SICA as a budget allo-

cation, which we should have. However, what I think we have achieved, even with the Central American Parliament (one of the agreements we signed), is to make strategic alliances. I believe there is more recognition of the CTCAP by the SICA.]. Interview with RMAL, May 27, 2010

This transcription indicates that the relation between the CTCAP and the SICA is anemic. The lack of a functional relationship between these organizations should be understood as part of a regional institutional deficit in understanding the role of STI policy in economic development, especially as a consequence of the missed link between public interagency cooperation at the national level on STI policy issues (Intrakumnerdi & Chaminade, 2007):

[... Then there is no organic structure that is institutionally interrelated with the rest of the forums as part of integration [processes] to have a joint working program or activities to be developed jointly. We have some points of common interest, such as one of the subjects carried out by the Secretariat, which I think will become more relevant now with the agreement with Europe, the Quality System.]. Interview with JCG, June 02, 2010

Central American countries adopted some organizational features from Mexico's National Council of Science and Technology (CONACYT), such as the case of El Salvador, Guatemala, Honduras, and Nicaragua. In the case of Guatemala, the Council has an executive body, the National Secretariat of Science and Technology. On the other hand, Costa Rica has ministries, and in the case of the DR, the ministry also regulates the higher education system. Panama has a somewhat different model consisting of a National Secretariat of STI under the Presidency of the Republic (OEI, 2014). The extended scheme of CONCYTs has a critical defect: a low political hierarchy. A more detailed review of the institutional

evolution of the countries of the Central American isthmus can be found in the work of Viales-Hurtado et al. (2021) and for the Dominican Republic in the work of Gómez-Valenzuela (2020).

It led to the third layer related to the encapsulated rationales and representation of STI policy in CA and the DR. It is essential to highlight the efforts in the last two decades in promoting STI policy integration throughout regional mechanisms such as the CTCAP. It also includes the support of international cooperation initiatives supported by the Inter-American Development Bank, the World Bank, and bilateral cooperation (Casale & Buenrostro, 2014). An implication in Central America of the mix between the linear supply-side model of innovation and Mode 1 of knowledge production for Central America is that the business sector becomes a passive receptor of university research activities:

[As 'Science and Technology [representatives], we carry out the research, but the missing piece is the application of our findings. So, our commitment is to provide research that can be applied. Then it is a process: research alone cannot be the goal. It must be applied, which should be done by the private sector.] Interview with RMAL, May 27, 2010

In practical terms, at the regional level in CA, the idea that basic sciences and fundamental research should be the focus of public policy still prevails:

[We have begun to realize in the region that S & T are the basis for developing any country, and we have had examples of countries like Taiwan. They bet on their research strengths and sent their people to be trained in the areas that they considered essential and [their people] returned (because the critical thing is to get the talent back to allow for the application of the knowledge, and not to allow the brain drain).] Interview with RMAL, May 27, 2010

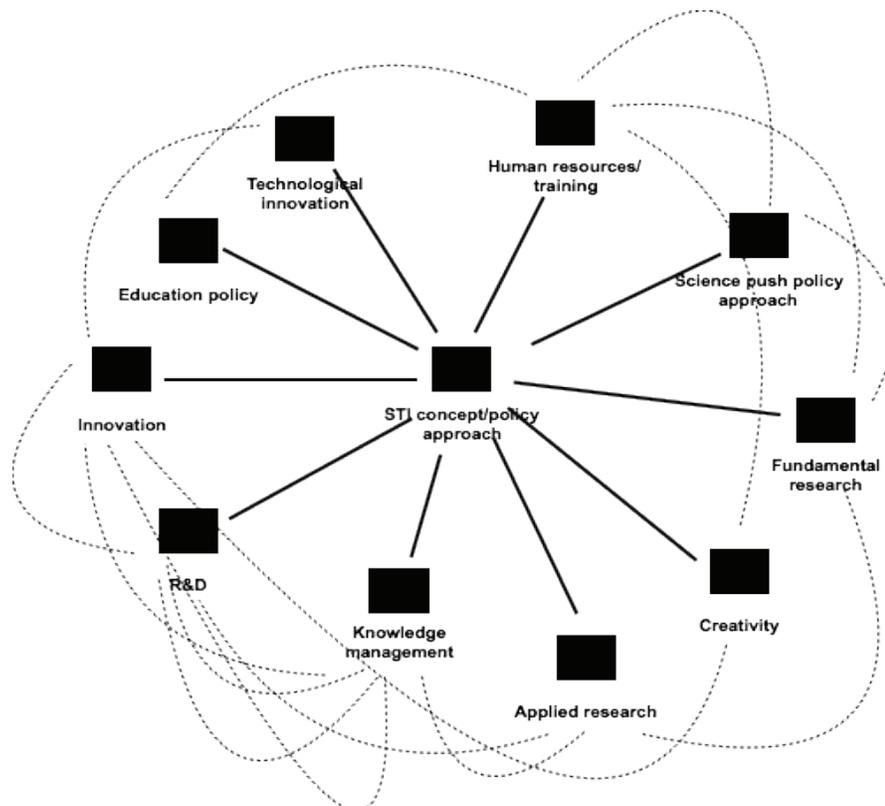
Mode 1 and the linear supply-side model of innovation, in the political context of CA, share the same neoclassical perspectives and rationale about the sources of the scientific and technical knowledge (universities, research centers) and the way that it should be widespread as a knowledge spill-over fostered by vertically oriented STI policies. According to HF, there is no doubt about the dominance of the mix of Mode 1 and the linear supply-side innovation model:

[The CTCAP still maintains the linear model of innovation 1, which, by definition, is oriented to basic research based on the idea that from the knowledge produced or the results of this

research, the practical applications will flow to the fertile fields in the specific scientific disciplines or in its various market applications, which is a situation that is far from happening.]. Interview with HF, May 27, 2010

In other words, in the CA countries, a supply-based approach prevails, at least in the public discourse of some policymakers, dragging the lack of influence of STI policy concerning the conventional set of designed integration mentioned above. Figure 2 on STI models includes the common elements in the different interviews and shows the mental loop as a space of interaction of perceptions.

**Figure 2**  
*Elements of the STI conceptual map*



In Figure 2, four elements have the highest level of interaction: knowledge management and R&D spending (with four interactions each), followed by the representations of innovation and human capital with three interactions each. These representations obtained from the analysis of the interviews reflect, in principle, a level of conceptualization that contains the essential elements that define the activities on which an innovation system is centered. At the same time, these representations indicate the explicit recognition at the regional level of the importance of STI policies in creating opportunities for economic growth and social development but from an aspirational and long-term perspective (Casale & Buenrostro, 2014; Padilla-Pérez & Gaudin, 2014; Viales-Hurtado et al., 2021). However, it can become in kind of policy gap, which can operate as a political and cultural barrier that prevents STI policies from being effectively incorporated into decision-making dynamics in the face of short- and medium-term economic challenges, such as those generated by the COVID-19 pandemic at regional and national levels.

Taking the different perceptual elements of Figure 2 indicates the persistence of a linear perspective related to STI policies (Viales-Hurtado et al., 2021). Such linear perspective in Central American countries' considering asymmetries in capacities and relatively low resources allocated to STI can be counterproductive in terms of the practical political action of STI policies and their eventual contribution to the dynamics of development and economic integration both at the regional and national levels (Bonilla & Serafim, 2021).

In terms of mental models and policy rationales, these findings point out the persistence of STI policy in the integration process as an end-model, which primarily contains perceptions and information about what policymakers are trying to accomplish regarding STI policy to support the integration process. However, without reaching a mean model leading to a plan of action to carry out the policy

objectives. Thus, the policymaking process fails to translate an STI policy rationale at the decision-making level and into the policy domain for development and economic integration. Thus, there is a fragmentation of the rationales which may support an efficient adoption of STI policy as a tool for development, creating a considerable institutional coordination gap between STI public organizations and the business sector (Dutrénit & Puchet, 2017; Magro et al., 2014).

In this regard, and considering the sharp contextual differences, the central American experience in integration is far from the European integration experience. It moves from the mean model perspective to the end-model policy actions through specific STI policy plans and institutional mechanisms to address the asymmetries in STI capacities of European Union members, covering social and cultural spheres concerning the role of STI in society (Ulnicane, 2015). In the case of Mercosur (Cimoli et al., 2009; Cimoli et al., 2005), the policy focus has been more oriented to the strength of STI policy at the national level than the regional level, despite the recent efforts of STI policy integration centered in the university system (Cassiolato & Lastres, 2000; Perrotta, 2016).

The Central America mental models gap also has clear STI rationales elements related to the neoclassical perspective in recognizing market failures affecting knowledge production and diffusion at regional and national levels. This neoclassical perspective is also related to the linear perspective on innovation by justifying the massive government intervention supporting basic science and fundamental research through public organizations such as universities. The mechanism as SIECA sees STI policy in the fenced realm of basic research. Figure 3 shows the different elements and barriers which may affect the translation of the positive perception of STI policy into an end-model or explicit policy course of action.

**Figure 3**  
*Elements of interactions of the mental map of STI policymaking*

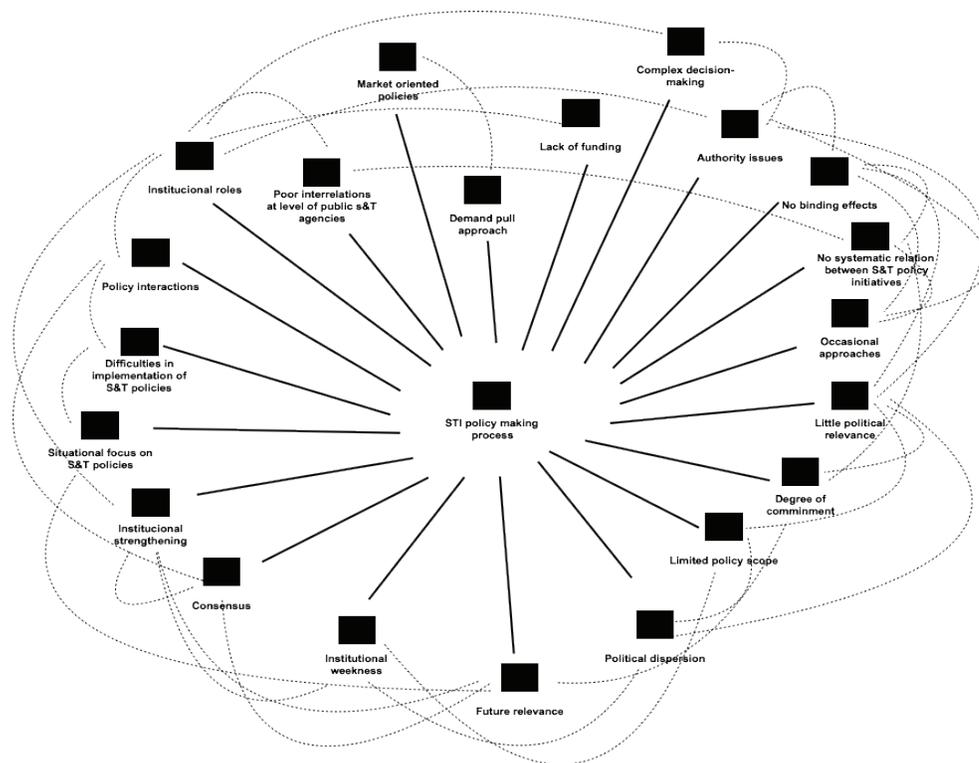


Figure 3 attempts to capture the perception of the translation process of the representational elements (mean models) that constitute the conception of the STI policy to the decision-making domain into end models, highlighting the policy gap in Figure 2. Even if the perception of the positive role of STI policy in economic integration dynamics can be translated into end models intended to open a path of implementation of STI policy, a vast implementation gap can be found at the regional and national levels. It is because several factors in Figure 3 act as institutional or organizational barriers, such as the poor interrelation between policy actors, the agency problem in terms of diffuse institutional role, and the lack of funding, among others affecting the

implementation of STI policy at national level or creating an empty policy space at the regional level. This empty policy space covers the shortcomings and policy failures related to the regional structural deficits in the coordination of different actors and STI-related agencies, which operates at a different level with their agendas and sharpen the coordination failures (Magro et al., 2014).

More than the interactions of the different elements, the concentration on the right of Figure 4 of the interactions between various representational elements is striking. Such interactions connect to the non-binding effects of the actions in STI policies, with the lack of systematic relationships between the STI

policy initiatives, the dispersion of the actions, the little political relevance, and the questionable degree of commitment of the actors of the public policy level, pointing out the relevance of institutions in innovation systems at different scales (Nelson & Nelson, 2002). Figure 4 also shows some barriers, such as the institutional weakness of the ONCYTs translating into the weakness of regional mechanisms such as the CTCAP and the relatively low interaction with other related agencies at the national and regional levels (Casale & Buenrostro, 2014).

As shown in Figure 3, the STI policymaking process in Central America at the regional level hides a vicious policy cycle affecting the contribution of STI policy to the integration process, circumscribing STI to concepts and terms such as applied research, the consensus at the policy level and interaction between public STI agencies but also by the complex interaction at the conceptual level amongst them (Bonilla & Serafim, 2021; Casale & Buenrostro, 2014; Laranja et al., 2008).

The depicted situation points out at the same time the opaque policy context in which the STI policymaking process is embedded and the limitations of such a process. It directly references the institutional weaknesses of STI policymaking (Padilla-Pérez & Gaudin, 2014). These weaknesses include no binding effects of STI policy, the lack of funding for policy implementation and STI policy instruments, and poor interrelations among public agencies at the national and regional levels (Casale & Buenrostro, 2014; Magro et al., 2014). One of the institutional weaknesses of public STI organizations was highlighted by FG:

[These entities [national organizations of science and technology] were born subordinates to another organization, a weakness in the region. All ONCYTs [national science and technology organizations] depend on a higher organization [a Ministry, Secretariat, or national direction].

Therefore, such organizations were not born with the political hierarchy they should have. I think there is a congenital disability to be tackled in each country, and Central American countries' challenge with the CONCYTs comes from their initial conception.]. Interview with FG, June 02, 2010)

A clear consequence of the gap between public and private actors is poor funding for R&D and innovation activities favoring university research. The weaknesses of the STI policymaking process identified are consistent with the results obtained by other authors, who identified several weaknesses concerning STI policy. It includes the lack of high-level political commitment, low investment, low enforcement capacity, monitoring and evaluation, and low institutional development of public STI organizations, among other factors (Padilla-Pérez & Gaudin, 2014). In addition, the non-binding effect of the decision-making process of the SICA system sends any possibility of STI policy dialogue in the opposite direction (Casale & Buenrostro, 2014). Both HG and JCG recognize the poor role played by STI policies in the regional integration process and its side effects in terms of the marginal role of the business sector:

[We believe that we should come closer to the economic forum because one of the weaknesses of the ONCYTs is that they have been closely linked with the academic side and little connected with the economic mainstream: with innovation efforts, businesses, with productivity. So, the CTCAP must make some approaches or alliances with Central American economic forums.] Interview with HF, May 27, 2010.

An explanation of the isolation of the business sector could be found in the non-binding effect of the general policymaking process and the lack of organic integration of the different components of the SICA system. Once again, the agency and the coordination problems arise as key factors explaining the lack

of effectiveness of STI policy in the multiscale SICA policy space (Flanagan et al., 2010; Magro et al., 2014). JCG explained the institutional consequences in the following way:

[Integration organizations are consulted, but their opinions are not binding. Worse, because it is an intergovernmental scheme, decisions must be taken by consensus. Decisions must keep circling for a country that disagrees until a consensus solution is reached, weakening governance. I think that more than a typical situation of the CTCAP, it is a problem with the institutional integration system. Integration organizations generally have little relevance: some more than others, but governments make the decisions overall.]. Interview with JCG, May 26, 2010

On the other hand, it is possible to find specific STI policy rationales in the National STI policy framework at the national level. In some specific cases, the linear supply-side model has been questioned (Laranja et al., 2008). It was the case of Costa Rica, with its National Plan of Science and Technology (MICIT, 2011), which explicitly recognizes the non-linear nature of knowledge production and discusses its economic implications at the level of firms, assuming a more Schumpeterian growth approach (Gómez-Valenzuela, 2020; Laranja et al., 2008). Additionally, the case of Panama refers to the non-linear perspective on innovation in its National Strategic Plan for Science Technology and Innovation 2006-2010 (SENACYT, 2010).

The mix of STI policy perspectives, rationales and representation depicted above and the dominance of the policy of things at the national level indicates a non-clear and incoherent path in the definition of STI policies at the regional level regarding the integration process. Therefore, the integration process has not considered the STI policies an element of such a process. Despite the existence and efforts of organizations such as the CTCAP and the SIECA, it indicates that, at the regional level, the limited progress

achieved has resulted from autonomous institutional dynamics derived from the extrapolation of the policy of things from the national level.

Under the policy scenario depicted above, except for Costa Rica and, to a lesser extent, Panama, even with important limitations (Casale & Buenrostro, 2014), STI policies at the regional level to date have been nothing more than a more aesthetic type of effort (Padilla-Pérez & Gaudin, 2014). In the case of DR, the country is a latecomer in STI policies (Gómez-Valenzuela, 2020). Despite recent advances, it still has a long way to go, especially to understand the specificity of STI policies and their synergistic articulation with the more conventional development policies. Finally, considering the effects of the COVID-19 pandemic, everything seems to indicate that the conceptions about STI policies have not changed substantially since the interview date.

The literature suggests that when considering the complexity of incorporating STI policies in a regional integration process, two related dimensions should be considered: a straightforward policy mix approach and a multilevel governance approach that can be adapted to local characteristics and take advantage of the synergies that may exist at the level of the different territories (Flanagan et al., 2010; Magro & Wilson, 2019; Vītola, 2014). For this, the definition of a policy mix approach will require the identification of STI policy instruments that can be applied in the different areas of the integration process at the regional level, as well as in the different subnational STI policy systems (Lanahan & Feldman, 2015).

Based on regional approaches and multilevel perspectives, the policy mix approach may have a more positive character at the first regional level. At a second national level, it may have a more normative character to the diversity of cultural and economic instruments available at the national level (Laranja et al., 2008). An advance in this direction can be found in the work of Gómez et al. (2020), who developed a joint analysis for innovation policies in

the D. R. In the case of multilevel governance, it is possible to design STI policies that operate at different levels of the integration process.

The orientation of policies from the national level to local territories must be linked to regional efforts in terms of integration. Specifically, strengthening national science and technology organizations is a requirement that must run in parallel with the efforts to design policies and promote a public-public and public-private dialogue on cross-cutting STI policies. Regional mechanisms such as the Central American Bank for Economic Integration (BCIE) can play a more active role in promoting the articulation of national innovation systems, which are articulated with a regional perspective of competitiveness based on capacity building for STI and regional integration.

### **Concluding remarks**

One fundamental finding of this research is to frame the three layers that restrict the role of STI policy in the integration process of CA and the DR, as well as the limitation of translating the perception about the positive role of STI policy in supporting the regional integration process. Of course, additional and complementary research is required to depict the current policy scenario at the regional level because of the COVID-19 pandemic. In the case of Central America and the DR, the scattered efforts in terms of STI policies have not evolved in the face of the economic integration process.

Another relevant finding of this study is the persistence over time, at least in the Central American context, of a clear linear perspective of STI and its relationship with development dynamics (Viales-Hurtado et al., 2021). The interviews used in this article are dated 2010, and one of the articles cited from the year 2021 acknowledges the persistence over time of this linear perspective in the STI policy documents analyzed by the authors. This persistence of linear approaches can be counterproductive in the Central

American and Dominican context, primarily due to the need to achieve a more mission-oriented or transformative approach to policies that allow dealing with the social, economic, and environmental challenges of the region and the countries, accentuated by the aftermath of the COVID-19 pandemic (Diercks et al., 2019; Villa et al., 2020).

Incorporating a regional STI policy as a critical component in the integration process of Central America implies that other STI policy rationales are to be explored to create a mix of policies and instruments that will lead to overcoming the current regional STI policy inertia. Thus, this research points out the relevance of STI institutional stability as a crucial factor in developing a differential STI policy pattern in terms of the slight differences in institutional development to be found in CA and DR concerning the mental representation of the role of STI in promoting economic development and in fostering the integration process. At the same time, the paper accounts for the different efforts through time at the regional level to incorporate STI policy as part of the integration process deployed after the creation of the Central America Integration System (SICA).

The COVID-19 pandemic revealed the structural shortcomings of the national socio-productive systems in CA and the limitations of regional integration capacities and had a wealth-destroying effect in all countries. This situation is complex and contrary to what might be thought at the level of national and regional public policy actors. STI policies can play a constructive role that improves the resilience of socio-productive systems in the medium and long term.

The risk is that under pressure to address the challenges of post-pandemic economic recovery and in the presence of a limited understanding of the potential of STI policies, instead of bringing STI policies closer together, they are moving away from the national or regional political landscape. Regional STI mechanisms such as the CTCAP and the primary economic policy mechanism SIECA,

including financial organizations such as the BCIE, should increase their formal collaboration to build a regional and comprehensive STI policy frame. This collaboration could include designing a new *policy mix* approach to deal with the regional variability and overcome the ‘policy of things,’ implying a more structural and comprehensive perspective on STI policy and development. It could imply moving STI policy at the regional level toward a mission-oriented and transformative policy approach to support a more relevant role of STI policy in the integration process. It could be a fundamental policy change, considering the medium-long-term aftermath of the global conjuncture and its impacts on the small open economies of Central America and the DR.

A first step could be to promote the high-level STI interagency dialogue, starting with the SICA and its integration organizations. The second step is identifying specific mechanisms and resources to build the new technical regional setting on STI, including agencies, universities, business schools and the business sector. These two steps can be summarized as the need to promote participatory dialogues on the role of STI in building capacities for development and for addressing the challenges and structural challenges facing the region as a whole and, of course, at the level of each one of the countries that are part of SICA. These dialogues must be participatory and operate at different scales and levels of governance, actively articulating civil society, the business sector, and governments. Their incentives are in sight: overcome the political inertia that has prevented a more constructive role for STI in the region and find new ways to address the challenges arising from the pandemic and the growing political, economic, and commercial uncertainty at the international level.

For further research, several complementary approaches are required to complete a more precise STI landscape in Central America, including a strategic management perspective, an institutional analysis,

and data gathering through innovation surveys carried out at the regional level. The methodological approach followed in this paper is binding on the Ground Theory perspective, and it showed suitable to provide an inside perspective of policymakers and their perception of the role of STI policy at the regional level. Any limitation from the methodological perspective is subject solely to the author’s perspective and constraints.

In the same way, the persistence of the linear model both in the representation and the discourse of STI policies at the regional and national levels demands training and capacity-building actions of regional and national scope both in the academic field, in the business sector, unions, social actors and with decision-makers. These actions should emphasize the need to move the STI policies of the region towards more contemporary approaches focused on the missions and challenges that the region demands in terms of transformation for the achievement of sustainable development objectives and development challenges in productivity and social cohesion accentuated by the aftermath of the COVID-19 pandemic. These new approaches must be approached from a more integrated short, medium, and long-term perspective that considers the definition of the most appropriate mix of policies and related instruments for each socioeconomic context based on strengthening the STI institutional framework and robust approaches to gender equity and social inclusion.

One of the theoretical values of this paper has been to put into perspective the persistence of linear approaches in representing STI policies in Central America and the Dominican Republic. However, although the findings presented are consistent with other studies highlighted in this paper, they are limited in terms of their temporal, sectoral and spatial scope. This limitation highlights the need to continue deepening the analysis of STI policies from a regional, national, and subnational perspective, to improve their formulation, design, and implementation processes so that they can be incorporated as

part of the set of measures that allow overcoming regional and national challenges in terms of sustainable development and social inclusion.

Finally, to move forward with STI policy at the regional level is mandatory: first, to assume a long-term commitment; second, to adopt a strengthened multilevel perspective of the institutional setting on STI policy. It requires institutional stability, coordination efforts, and policy relevance of the STI institutional setting at the regional and national levels.

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