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Navigating challenges: STI policies for sustainable and inclusive development in Latin America

Pietrobelli C., Anlló G., Barletta F., Bianchi C., Dutrénit G., Menéndez M., Puchet M., Rocha F., Ruiz K., Segura Bonilla O., Szapiro M.

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Navigating Challenges: STI Policies for Sustainable and Inclusive Development in Latin America

Pietrobelli C., Anlló G., Barletta F., Bianchi C., Dutrénit G., Menéndez M., Puchet M.,
Rocha F., Ruiz K., Segura Bonilla O., Szapiro M.

Maastricht, 13 November 2023

Abstract

This paper explores the challenges and opportunities for Latin America in adopting sustainable development strategies, with a particular focus on Science, Technology and Innovation (STI) policies. It gathers the insights of a group of distinguished scholars on STI policies, social inclusion and sustainability from the region who participated in the panel organized by the UNESCO Chair during the LALICS* conference held in Asuncion, Paraguay, on 19-21 June 2023.

It addresses the challenges that hinder Latin America's inclusive, sustainable and innovative development process from different perspectives. Highlighted challenges include strong inequality, high informality levels, and low R&D expenditure, heterogeneous productive structure posing obstacles to innovation and their governance. Scholars highlight the role of STI policies and the engagement of academia, government, and business in reducing inequality and promoting social protection, and discuss the technological capabilities needed to address climate change and digitalisation in the region.

J.E.L. E61, O31, Z18

Keywords: Science, Technology and Innovation Policies, Latin America, Sustainability, Development

The UNESCO Chair on “STI Policies for Sustainable Development in Latin America” is a partnership between the United Nations University UNU-MERIT and the UNESCO Regional Office for Science in Latin America. Its overall objective is to create and strengthen the expertise of policymakers and researchers on Science, Technology and Innovation (STI) policies in Latin America. To this aim, it is important to discuss the position of the Latin American region and its virtues and challenges when initiating virtuous processes of technological innovation to reduce inequality and promote social inclusion in a context of a green and digital transition.

* LALICS is the Latin American Network on Learning, Innovation and Competence building (www.lalics.org).

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María de las Mercedes Menéndez and Carlo Pietrobelli

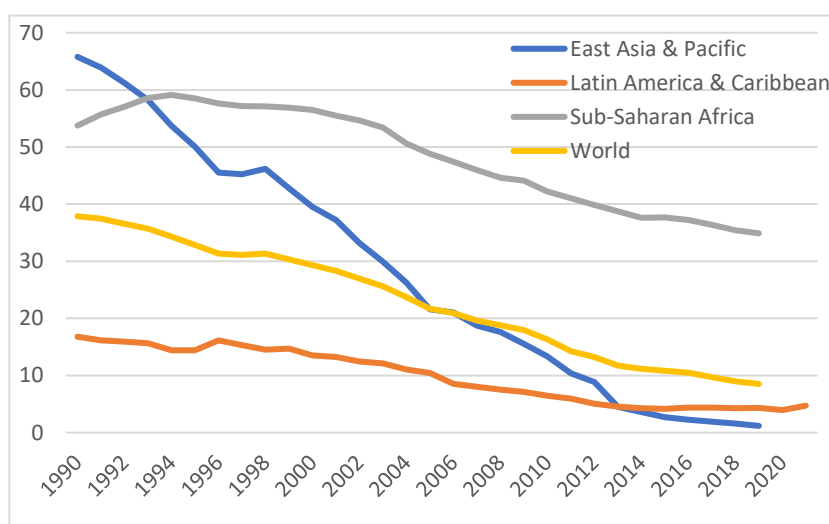
STI Policies and Environmental and Social Sustainability

Countries worldwide face the challenge of reshaping their development strategies towards a more sustainable use of resources, modes of production, consumption and lifestyles. The shift towards a green economy is not new and has become increasingly relevant as a strategy for countries after COVID-19. Undoubtedly, Latin America is no exception to this, and adopting such new development strategy may open the door to new opportunities and challenges, despite the region's structural development constraints. While green windows of opportunities may come with renewable energy strategies (UNCTAD, 2023), the region is one of the most vulnerable to climate change (OECD et al., 2022), making the green transition especially difficult. Furthermore, to achieve a fair green transition it is necessary to strengthen the social protection system, promote the formalization of work and reduce inequalities between peoples and regions (OECD et al., 2022; Tavares, 2022).

The following dimensions summarize the top challenges of green and fair transition that Latin America faces today:

Weak social protection system: One of the region's limitations for a virtuous insertion in a sustainable development strategy is the improvement of social conditions. In this respect, Latin America and the Caribbean experienced a decline in the poverty rate (as a percentage of the population) during the first two decades of the 2000s. However, since 2014, the region has seen a reversal of this trend, diverging from the East Asia and Pacific region, which has reduced its poverty rate by a far greater magnitude. Another structural limitation is the persistence of high levels of informality in the region. In this regard, informal and mixed households account for two-thirds of the population (OECD et al., 2022). Decarbonization could generate 15 million jobs in Latin America by 2030, around 4% of the region's total employment, which could be integrated into the formal labor market and upgraded through environmentally related activities (Saget, Vogt-Schilb and Luu 2020).

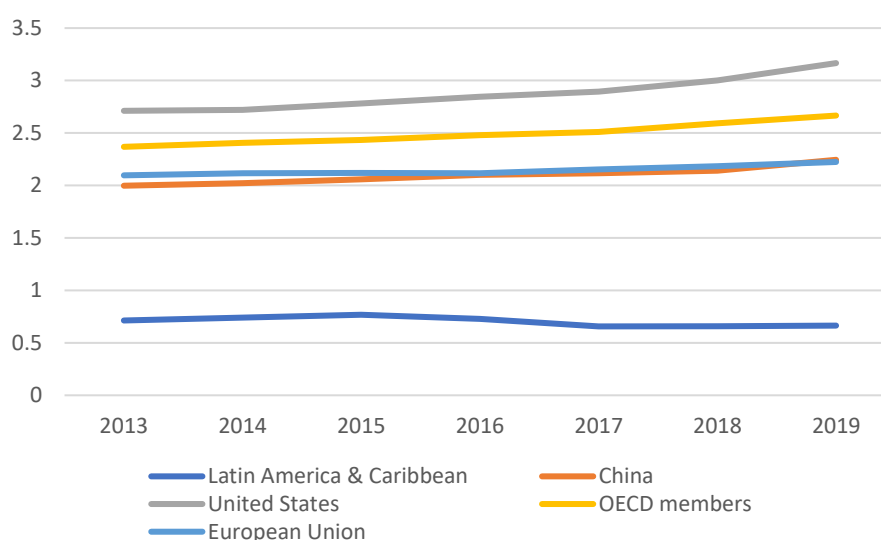
The poverty gap is falling slowly in LAC (at \$2.15 a day, 2017 PPP) (% of the population)



Source: World Bank

Remarkable obstacles to innovation: The green transition requires advancing the current state of STI in Latin America and overcome the structural constraints that bind its development. According to ECLAC (2022), R&D expenditure as a percentage of GDP is low, far below 2 %, when this share reaches 3% in the US and 4% in the Republic of Korea, and their implementation depends mainly on government support. At the same time, some positive trends emerge, as between 2000-2009 and 2010-2018, environmental patents in Latin America and the Caribbean more than doubled in relation to renewable energy, electric and hybrid vehicles and energy efficiency, among others. Latin America also has a higher share of environmental patents in total patents compared to other more developed countries such as the US and China. Even so, the proportion of researchers per thousand of the economically active population has remained just below 2 in the last ten years, lower than other Iberoamerican countries, such as Spain, which is around 10.

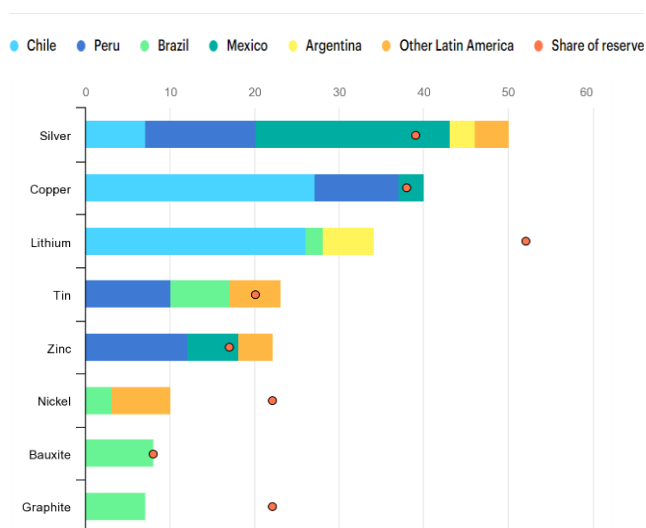
Research and development expenditures remain very low in LAC (% of GDP)



Source: World Bank

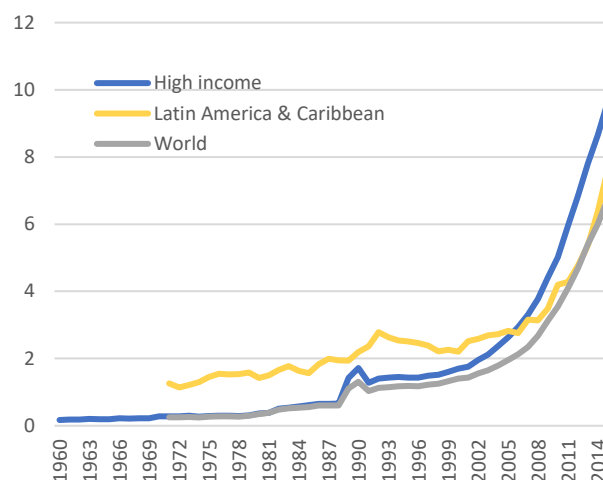
Renewable energy and natural resources: Latin America's virtuous green and digital transitions would imply deepening the region's historical productive specialization based on natural resources. In contrast to previous techno-economic paradigms, in the current one fossil fuels are being replaced by clean technologies. These clean technologies require many minerals, such as silver, lithium and copper, which are key to the clean transition. The Latin American region accounts for 35% of the world's production of lithium. This specialization can open "green windows" of opportunity that will depend on the criticality of the minerals and the countries' competitiveness in the mining industry (Valverde et al 2023). Regarding Greenhouse Gas (GHG) emissions, the region only represented 4.6% of total global emissions in 2019. Of these emissions, more than half come from the energy sector in Latin America. Greening this sector is still a challenge because still only 33.6% of the primary energy supply come from renewable sources.

Latin America has a large share of the production and reserves of many minerals, 2021



Source: Extracted from IEA

Electricity production from renewable sources remains lower in LAC than in other regions (excluding hydroelectric, % of total)



Source: World Bank

We have briefly reviewed some of the main challenges that hinder Latin America's inclusive, sustainable and innovative development process. The following questions emerge, and will be the object of this note:

- What role can STI policies play in reducing inequality and promoting social protection within the sustainability paradigm?
- What are the most important limitations to achieving scientific and technological development and social inclusion in a context of low innovation such as that of Latin America?
- What are the necessary technological capabilities to face climate change and digitalization in Latin America?
- What can be the roles of universities, the business sector and the government in promoting STI policies for social inclusion and sustainability?
- How can the outcomes and impact of STI policy on inclusive and sustainable development be convincingly measured?

The UNESCO Chair at the United Nations University UNU-MERIT organized a panel to discuss these issues during the LALICS conference, held in Asunción, Paraguay, on June 19-21, 2023. This note gathers the opinions of the following group of distinguished scholars from the region that took part in the panel.

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Gabriela Dutrénit

A STI policy with a social perspective

The countries of Latin America and the Caribbean report low scientific and technological capacities and innovation in relation to countries with a similar level of development (UNESCO 2021). A structural characteristic of the countries of the region are the high percentages of the population living in poverty and extreme poverty, and the strong inequality, which makes it the most unequal region in the world. Likewise, a part of the population is excluded from the benefits of science, technology and innovation (STI). Unfortunately, the COVID pandemic increased poverty.

Undoubtedly, increasing our STI capacities is a challenge, but we must connect it with the reduction of poverty, inequality and social exclusion and contribute to greater social inclusion.

This raises the issue of how the relationship between STI development and social inclusion should be. LALICS reflected on this issue in a workshop held in Montevideo in 2014, and prepared a Declaration entitled "Contributions from Science, Technology and Innovation to Social Inclusion". The focus of the debate was on how STI can help to solve the problems of social inclusion. STI policy plays a central role in answering this question. It was acknowledged that there is a plurality of approaches to the question posed, and that there is a diversity of actors that fulfill different functions. The participants agreed on the need to adopt a perspective of social inclusion, and several issues were raised.¹ I would like to highlight a few related topics for discussion.

1. We should clearly differentiate between a social STI policy and an STI policy with a social perspective. The latter is more appropriate since the STI policy is aimed at building STI capabilities.
2. What should be the balance between existing scientific capacities and efforts to generate problem-oriented science? This is an old question raised by Keith Pavitt (1998 & 2001), when he openly asked: "Should developing countries publicly finance academic research?". Pavitt argued that academic research (AR) is a public good, it does not have to be original to begin with, and indigenous investment in local AR skills and equipment is necessary even for imitation. Moreover, investment in local AR can provide capacity for local problem-solving, especially when linked to post-graduate training, and the output of AR tends to increase more rapidly in fields associated with national economic and social requirements. These arguments continue to be valid today.
3. When making STI policy decisions, in conditions of scarce resources, it is necessary to define what should be prioritized: (i) problem-oriented science to meet current national needs, with a short-term vision (ii) basic science to strengthen capacities and address national problems that arise in the future, with a long-term vision, (iii) basic science connected to the frontier of knowledge or science which only seeks to imitate, among other objectives. But, in addition to defining what is prioritized, it is necessary to think about what proportion of resources are allocated to each objective.
4. We need a balance between basic and problem-oriented science. The following points will demand careful discussion:

¹ https://www.lalics.org/wordpress/wp-content/uploads/2014/12/Declaracion_LALICS.pdf accessed on 10.10.2023.

- How should we identify national problems to focus on? The process is not that simple. The CYTED network “Science, Technology and Innovation Policies aimed at solving national problems” is reflecting on this topic.²
- Different trajectories could be followed: one could start from the major national problems and go backwards, building a tree of sectors and related knowledge areas, including the social sciences and the humanities, or start from the existing STI capacities and from there look at the national problems and define which ones can be addressed and what additional knowledge is required for this.
- Basic science needs adequate financing, because it is necessary to strengthen the knowledge base of any society.
- Consensus among STI actors is essential for any priority identification exercise, and will need to be continuously fostered.

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Martín Puchet Anyul

Problem-oriented participatory STI policies. Democratic Dialogue, Conflicts and Peoples’ Demand

The main question raised is how to formulate these policies through an approach that fully commits the parties involved to promote a development that is really inclusive and sustainable. Such a policy approach involves targeting specific aspects of national problems through STI activities.³

Latin America faces very diverse problems that influence all the sustainable development objectives. Many of these problems are raised by government entities, social movements, groups of people affected by conditions of poverty, exclusion or vulnerability, as well as problems that deserve priority on the basis of academic research, and the activities of government advisory bodies or non-governmental organizations. The conversion of such issues and topics into problems that require STI is an ongoing construction process and not an exercise subject to recipes or pre-established formulas.

If STI policies are not formulated on the basis of problems and from the point of view of the people involved, they are inevitably subject to tensions that, sooner rather than later, hinder them, lead to paralyzing confrontations or end up making them ineffective or non-existent. The problem-oriented approach fosters the positive solving role of policies, gives them a pace and facilitates their cycle of design, implementation and evaluation. The responsible consideration of the perspective of the interested parties – individuals and collective entities - makes it possible to acknowledge relative

² <https://www.cyteted.org/> accessed on 10.10.2023

³ Our network PCTI-LALICS of CYTED (named “PCTI orientada a la solución de problemas nacionales”) is intending to build a perspective in this sense: www.cyteted.org/PCTI-LALICS

powers, fields of confrontation and agreement, and frames of reference of those who participate in a decision-making process that will necessarily be shared.

The options of formulating policies from the top down, without explicit consideration of the interested parties and guided only by expert judgment, or the alternative of making them as specific responses to demands arising from the bottom up, have shown their inadequacy for progressively more complex societies, subject to ever broader and more complex challenges (Dutrénit and Puchet, 2020).

The essential components of the STI policy construction process are: i) the detection of the parties involved and the establishment of a democratic dialogue between them, ii) the consideration of the agendas of each participant and their demands in relation to the points raised. and iii) the appraisal by the participants and, in particular, by the promoters and facilitators of the dialogue, of the capacity of each interested party to express, that is, give voice, to the possibility to opt out of the dialogue as well as to institutionalize joint and comprehensive decisions through agreements and voting.

This approach to STI policy aims to propose how to conceptualize them and, at the same time, in the process of building these policies, spark a process of permanent self-monitoring, about the limitations and possibilities offered by this approach or alternative ones.

The proposed approach forces us to focus on some key elements: the conditions of the democratic dialogue between the parties involved, the forms that the demands and agendas take on each of their points and the degrees of conflict around the problem raised, and the disputes over proposed solutions.

The conditions that make the dialogue possible depend on how each participant's stand vis à vis the others, on the interactions she entertains the others, and in what social, economic, political or cultural relations she is involved with in reference to the problem to be addressed. Each participant asks these questions and, in particular, those who promote and facilitate the dialogue to produce STI policies also ask them from their point of view, which is not neutral, but aims at achieving results, or else transcending the perspectives of the other participants. Thus, from these conditions of possibility it derives that the problem-oriented approach to STI policies requires to stipulate a system of association. Such system includes the definition of the people and of the organizations involved, the description of the interactions established between them, the degrees of interaction or the need for its presence, identify the relationships that emerge from the interactions, and detect the types and sets of rules that condition, shape or interfere, hinder or prevent the relationships among the actors.

The system generated around a problem will develop according to its options and opportunities for self-control or self-governance. Governance will thus become a fundamental characteristic to formulate and solve the problem. Consequently, a sound knowledge of the demands and agendas of the participants is essential. The degree to which demands and agendas are formulated depends on the capacities of expression, the possibilities of leaving the dialogue to achieve what has been formulated, and the opportunities to reach agreements through assessments of the relative powers of the participants, that is, the putting into practice of voting mechanisms – consensus, majorities, weightings of preferences, etc., on the points raised.

The triple option: voice, exit or vote, is on the table of the democratic dialogue (Hirschman, 1970) from the very configuration of the STI policy problem. The conflict around this formulation is an organic part of this association. This means that imposing, agreeing or participating are possible actions at all times, and that, therefore, the multiple possibilities in which the voice, exit and voting options of the actors are combined will be relevant for the governance of the system.

The formulation of the problem is always stressed by the conflict and its multiple possibilities of resolution. Solutions to STI policy problems always belong to a field full of expectations and uncertainty. The relative powers that feed the conflict at the time of formulating the problem are probably lessened in the discussion about solutions. However, when the problem starts being addressed, there are many possible solutions that will generate controversies and the expectations that these engender will realign relative powers.

The STI policy construction process is governed by a continuous sequence of decisions. Therefore, the conditioning information, the criteria for deciding and the resulting actions will also be the object of the dialogue.

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Keynor Ruiz Mejías

Lessons Learned and Challenges of STI Policy Plans

One of the main reasons for developing policies, including those related to STI, is the goal of change. This change may be necessary either because doing nothing will not improve a particular situation or, worse yet, it will exacerbate existing problems, or because regardless of the future, a change in the direction of what is considered appropriate or desired is sought. In this regard, our countries have experienced several challenges in the development of national STI plans that do not necessarily lead to greater social inclusion and equity. However, key elements can be considered to ensure that these objectives become part of the policy, and academia can play a crucial role in some of them.

Perhaps one of the most relevant general aspects to consider is the rationality of policies. Rationality is not only understood as a rational and logical process in the abstract, but also involves clarity in the desired objectives, the envisioned future, available policy options, and the potential consequences or expected effects of specific decisions.

Identifying *where we want to go* is not just about imagining a different future but understanding the meaning of that future within the framework of the country's strategy. It is essential to ask, “What do National STI Plans respond to in terms of the country's strategy?” It is evident that STI policies do not solve all country's problems; they are just one component in the realm of science, technology, and innovation, which must be integrated and complemented within a systemic framework of policy development and implementation that makes up national development plans. This leads to several aspects that must be considered when formulating STI policies. First of all, broad guidelines for where the country wants to go and the capacity to achieve those goals need to be identified. This is an ongoing discussion, but policies should not be a mere compilation of good intentions; they must be

measured based on their execution and whether they bring us closer to those previously defined objectives.

Another aspect to consider is the participation of key actors in the formulation of STI policies. This participation cannot be regarded as passively receiving policies. The definition, formulation, and implementation of public STI policies necessarily involve the participation of the actors involved. Here, two relevant dimensions must be mentioned. One is the exclusion of certain sectors *per se*, and the other is the dynamic process of "participatory" workshops.

Regarding the first situation, some individuals and organizations still consider innovation solely related to high technology. This leads to policies that exclusively focus on activities involving high technology (regardless of whether they involve R&D or just industrial manufacturing), thus excluding traditional sectors. This situation also results in geographical exclusion, as high technology production in our countries is concentrated in certain areas with favorable infrastructure conditions (ICT, communication routes, ports, and airports), restraining the innovation opportunities for sectors and actors in less favored regions.

In this, the support of academia is crucial, not only to provide a better understanding of the concept of innovation, but also to conduct research that highlights innovations of diverse nature in traditional sectors and less infrastructure-rich areas. Identifying the innovative dynamics of different productive sectors does not only lead to more inclusive policies, but also implies opportunities for generating mechanisms of change and technological progress, driven by the creation and utilization of new knowledge, as well as national capacities and competencies for innovation.

Thus, more inclusive and diverse STI policies do not only acknowledge structural heterogeneity, understood as differences in the level of technology development and adoption among different productive sectors of the economy, but also generate more growth and benefits distributed among various productive actors. This is because the possibility of accessing innovation processes could generate wealth in multiple sectors and activities, not just those initially considered as high technology.

On the other hand, with reference to the second dimension, it is essential to emphasize that participation should not be a mere formal exercise where actors are invited to workshops to be co-responsible for the policy. A participatory process involves more than just listing problems and needs; it requires understanding them at the sectorial and strategic levels and proposing measures consistent with the proposed objectives to reach the desired future. Such participatory process should be constructive, involve sectorial discussion, followed by a multisectoral approach with the participation and interaction of different actors in the system, aiming for greater coordination and connection with the productive reality and country's capacities.

One last point to highlight is that STI policy is not the exclusive responsibility of the Ministries of Science and Technology; generally, these policies involve combined actions from Ministries of Economy, Labor, Agriculture, and Education, as well as the participation of Ministries of Finance and other actors responsible for policy implementation. It is inappropriate for governments to use the so-called "system leadership" as a tool to exclude other key actors. The problem with this approach is that the National STI Plan may be perceived as ineffective, as it fails to address or foster almost anything, and it may go unnoticed by most actors in the system. Furthermore, it is important to remember that the systemic approach does not emphasize the boundaries of the system, but rather the interaction of actors within the system and with other systems, ensuring that the scope of policies is determined by the characteristics of the problems rather than by the institutional scope of some actors.

Carlos Bianchi

STI Policies for Inclusive Development in Latin America: New Challenges and Old Problems

The great challenge for STI policy can be expressed as contributing to democratic, inclusive and environmentally sustainable development processes. In Latin America, this agenda for inclusive and sustainable development faces multiple challenges. Some of them stem from chronic problems in the region - e.g. lack of productive capacities; intra-regional heterogeneities, income inequality - while others are relatively new - e.g. environmental sustainability; gender equality -, and all of them are interrelated, showing the growing complexity of the development process. Dealing with these problems requires the creation and intensive use of knowledge in different areas. This calls for a discussion of the scope and limitations of STI policies in light of the experience of the policies applied in Latin America during the first two decades of the 21st century.

Among the structural problems that have affected the region in the long run, the evidence shows that in Latin America still prevail forms of production of goods and knowledge that contribute little to sustained economic growth. Far from considering economic growth as synonymous of development, it is necessary to recognise that it has represented a necessary condition for inclusive development processes in the region. The recent period showed the dramatic dependence on external conditions – e.g. commodity price cycles - for growth. In turn, inclusive development policies have depended, although not exclusively, on the sustainability of growth and are therefore exposed to the volatility of external conditions. One specific aspect of this concerns the contribution of STI policy to economic processes of structural change that make it possible to relax dependence on external cycles, as a necessary component of a socially and environmentally sustainable development strategy.

This implies the need to modify the production structure, diversify and make production more complex to be able to participate in markets with growing demand. In a virtuous systemic process, economic diversification and complexity co-evolve with the development of productive and technological capabilities. The experiences of structural change and sustained growth in some Asian and European countries during the 20th and part of the 21st century show that these changes are processes of creative destruction that require a political agreement of reallocation of priorities, selection of strategic goals and, by the same token, management of the inherent conflict.

However, the structural change agenda today faces new challenges and requires creative solutions to articulate sustainable and socially inclusive development processes. This means that some historical experiences that have been considered as a reference for analysing possible trajectories of structural change, typically the Asian cases of catching up in the 21st century, provide relevant lessons, but they are not models to follow in view of some of the central aspects of the current agenda. In this sense, a strategy based on high economic growth rates that increase inequality gaps does not seem viable, since we know that income distribution favours the formation of capacities in the social and productive fabric and that these are a necessary condition for the processes of structural change. In the same vein, a strategy of economic growth with environmental destruction is neither normatively nor technically viable, nor is a path of economic development based on authoritarian models of government normatively desirable.

In the face of these challenges, in the first decades of the 21st century, Latin American countries have deployed a wide range of STI policies, in some cases coordinated with industrial, health or environmental policies. Within the national experiences, policies were implemented with a necessary

experimental component, implementing systemic instruments; in other cases, canonical instruments were applied, especially within the logic of correcting "market failures". In all cases, even with important advances, there has been no substantive impact on the structural transformation necessary for inclusive and sustainable development. In general, STI policies in Latin America have not been implemented in a sustained manner, and some of the main goals have often been blocked by interest groups, or sometimes radically reversed depending on electoral cycles. As a result of that, the countries of the region have followed erratic building processes of technological and productive capabilities, which are necessary for sustainable development.

It has been argued that one of the main problems - but not the only one - in bringing about this type of change is the inability of Latin American societies to build long-term political agreements, sustained by solid and lasting coalitions, which allow the conflict inherent in the distribution of economic resources and power to be managed. In addition to the chronic problems of the region's historical development, I observe two aspects from the recent Uruguayan experience that, in my opinion, have blocked the formation of agreements for an inclusive and sustainable development policy.

Firstly, there is a distrust of public action, the State and the notion of collective well-being. This is manifested in the unwillingness to pay for public goods that are essential for development, and in the exit strategies of some agents to enjoy these goods privately. Likewise, in a framework where STI activities are acknowledged by different political stands as a key element for development, the State-market dichotomy still appears as an axis of discussion, sometimes conflict, and sometimes as a blockage for sustained policies in this area.

This is associated with a low intergenerational willingness for distribution. For example, taking lessons from Asian cases, the evidence shows that innovation-based structural change policies require going against market signals (get prices wrong). In other words, structural change must be driven towards sectors where there is no comparative advantage and competitive capacity at present, and the medium and long-term outcomes are uncertain. The agreements to promote these processes require giving up present benefits for greater future welfare, which makes it difficult to build support coalitions.

A contrasting example is offered by the Fund for Excellence in Education and Research (FEEI)⁴ in Paraguay. This fund was created in 2009 as a result of a revision of the agreement between Brazil and Paraguay in return for the transfer of energy generated in the Itaipú hydroelectric dam. By law, the FEEI was created as the entity in charge of managing a fund to promote education, research and innovation, with a percentage of the revenues from the revision of the agreement. This has allowed very significant qualitative changes in Paraguay's incipient research and innovation system. The continuity of this type of initiatives is essential for the sustained formation of capacities necessary for a virtuous process of development.

However, despite the previous example, in the most developed Latin American STI systems, the inertia or blockages to implement processes of change in productive structures are also observed in the institutional framework of support for productive development and innovation. Processes of creative destruction are needed not only in production and technology, but they are also necessary at the institutional level, where new organizations and institutions replace the previous ones. In the Uruguayan case, for example, some necessary articulations between STI and productive development policies have been blocked by the institutional framework, which was designed many decades ago.

⁴ <https://feei.gov.py> accessed Nov.10, 2023.

In sum, STI policies should be considered as part of a development policy, the content and complexity of which has grown and will surely continue to grow. One of the components where STI and development policy need to be coherent is in the productive transformation agenda. This is a long-standing concern in Latin America. Without claiming novelty, I would like to emphasise here that, to contribute to a growing complexity development agenda, STI policies need long-run agreements sustained by wide coalitions of support. This requires accepting that the State has a relevant role to achieve public objectives, as well as the need to transform itself creatively.

Marina Szapiro

Systemic Industrial and Innovation Policies for National Challenges and the need to articulate social demands with the economy

The analysis of the main transformations in the global dynamics of production and innovation since the international financial crisis of 2007/08 – characterized by low real GDP and trade growth, a reduction in investment in productive activities and deindustrialization - and the changes in developed countries' industrial and innovation policies indicate the need for developing countries to rethink their industrial and STI policies (Cassiolato et al, 2021).

Developed countries have been increasing both protectionism through the adoption of tariff and non-tariff barriers, and the use of foreign investment screening mechanisms (Evenett, 2020 and OECD, 2020). The generation, adoption and diffusion of new digital technologies have been the focus of new industrial and innovation policies in advanced countries, targeting their reindustrialization and the strengthening of the national productive base. Moreover, large multinational companies, supported by the governments of their countries of origin, have been implementing reshoring strategies, seeking to bring back production tasks that were previously displaced to countries with lower production costs.

Overall, the objectives of the industrial and innovation policies adopted recently by the most developed countries are the strengthening and protection of the local productive base and of their domestic companies, the thickening of local production chains and the diffusion of new digital technologies. Thus, the global production and innovation dynamics changed the policy space for industry and innovation in developing countries.

First of all, it is important to consider that traditional policies based on trade opening and liberalization measures, and those aimed at attracting multinational companies and insertion in global value chains, which were suggested by international organizations to developing countries over the last years, should be definitively left out of the debate. In a context in which developed countries have been increasing the protection of national industry and of the domestic companies, and have been implementing efforts to bring back productive activities previously transferred to countries with lower production costs, the room for State action and public policies in developing countries needs to be rethought.

Therefore, we propose that it is necessary to develop new approaches to industrial and innovation policy that are focused on the solution of national challenges and problems, and are capable of articulating social demand with the economic dimension (Gadelha, 2016).

As it has been strongly emphasized by the Latin American literature on industrial and STI policy, the coherence between implicit and explicit policies is vital to achieve STI goals. New approaches are required to design a new systemic industrial and innovation policy. The traditional vertical (sectoral) or horizontal industrial and innovation policy approaches have become extremely limited considering the challenges faced by developing countries and the changes in the global productive and innovative dynamics.

Instead, we propose the alternative to design industrial and innovation policies oriented to the solution of major national challenges. The challenges must be defined in the policy arena, considering the specific context of each country based on a national development plan. In this case, industrial, scientific, technology and innovation policies are no longer considered as independent, but they are essential and interdependent parts of a development strategy to solve great national challenges.

The major challenges should constitute the central axes of a new conception of industrial and innovation policy in developing countries. The challenges are specific to the national, regional, and local context of each country, and its definition should consider the historical, economic, institutional, and political stage of the country, as well as its international insertion in global geopolitics. Industrial and innovation policies oriented to the solution of national challenges allow the establishment of connections between the productive sector and the demands of society based on a strategic orientation. The development of production and innovation capabilities must become conditioned to the objectives of the national development plan.

It is important to emphasize that the development of new approaches to industrial and innovation policy also demands an institutional restructuring process, as well as the creation of new mechanisms for articulation with the business sector. The institutional framework required for the design and implementation of industrial policies oriented to the solution of great national challenges is new and different from the previous one.

In this context, the systemic approach to innovation can contribute to the development of new approaches to industrial and innovation policy based on a national development project focused on the solution of major national challenges. The articulation between social demand and the economic dimension (industry and innovation), as well as the coherence between implicit (e.g. especially the macroeconomic regime) and explicit policies, should represent the basis of the new industrial and innovation policies. Some examples of national challenges that could become objectives of industrial and innovation policies are a stronger universal health care system; a better urban mobility and energy transition, including the development of new energy sources.

In the case of the national challenge of strengthening the public health system, the need and opportunity for articulation between the social demand for public health services and the development of the productive and innovative base are easily perceived. They represent an example of a systemic industrial and innovation policy focused on the solution of a national challenge.

From 2008 to 2015, in Brazil an industrial and systemic STI policy aimed at strengthening the Health Economic Industrial Complex was implemented through a combination of different policy instruments that included: public procurement, support for R&D activities in the pharmaceutical industry, technology transfer to produce drugs and strategic products for public health system, support to public and private laboratories, among others (Szapiro et al, 2016). The coordination of this policy was carried out by GECIS (Executive Group of the Health Economic Industrial Complex) which involved several ministries, in particular the Ministry of Health, the Ministry of Development, Industry and Commerce, and the Ministry of Science, Technology, and Innovation. This policy was discontinued in 2016, and it is being resumed by the new government of President Lula since the beginning of 2023.

It is important to remark that the systemic industrial and innovation policy for the universal health care system has produced relevant results in terms of the development of local production and innovation capabilities and of a strong national productive base.

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Guillermo Anlló

Going back to the sources: simplifying the analysis to respond to an increasingly complex scenario. Today a system to foster substantial creativity and redesign of STI policy instruments and institutions is required

We are living in a complex reality, characterized by a dynamic of vertiginous change, which makes public policies' planning and interventions increasingly difficult and demanding. It is precisely this reality that continuously challenges the public sector to respond to multiple and interrelated demands, which drive an institutional dynamic built on multiple "geological" capabilities accumulated over time.

Public policies are carried out through the institutional framework built by the public sector for this purpose. In the specific case of STI policies, this institutional framework began to be built more than 70 years ago, based on an initial demand that came from the need to develop scientific capabilities. In other words, public policies were then science policies, which were born out of the idea that progress and development depended on scientific knowledge, for which it was necessary to possess these capabilities. This model is known as the "linear model", and is basically aimed at generating a scientific system, for which it is necessary to train human resources - scholarships and postgraduate careers -, establish adequate infrastructure - investment in laboratories and universities -, and open lines of financing - through subsidies, allocated directly or through competitive processes. As a result, it was expected to see an increase in the number of scientists, publications and patents, thus contributing to increasing scientific knowledge.

A little later, what was called the Southeast Asian “miracle” showed the world that countries from that region could develop without necessarily possessing these scientific capabilities, at least not to the extent of the developed countries, and that they began competing with advanced countries on an equal footing in global markets. Moving beyond the surface, what these countries had carried out were technology policies, which, contrary to science policies, had focused more on copying, adopting and generating certain technologies associated with some strategic sectors that had been previously selected. They truly represented development bets, where the "winners" were picked and promoted. These techno-productive decisions, with their focus on technologies, implied the need to copy, adopt and adapt technologies. The process generated technological capabilities, a certain type of knowledge, and finally, with the maturation of the whole process, new knowledge and scientific capabilities to drive the policy, now, indeed, a science policy. Thus, sometimes this movement was interpreted as a shift from a "supply-driven" to a "demand-driven" STI policy. Within the linear model, the shift was from one extreme - the creation of knowledge – to the opposite extreme - facilitating the impulse to generate relevant knowledge from the demand for such knowledge.

We did not abandon the matrix of interpretation of reality, and institutions and instruments that were being applied were not modified, but the emphasis and who decided what to do both changed.

Finally, at the end of the XX century, the notion of innovation was incorporated, where it was observed that innovations did not depend exclusively or necessarily on scientific knowledge. In turn, many other variables acquired new relevance – e.g. institutional rules, agents' behavior, the financial system, international treaties - that made it possible to encourage more innovations and contribute to a better developed society, with greater capacity to respond to increasingly complex social challenges.

Lately, we have also begun to observe that not just any innovation is desirable, but that it is important before innovation to be sustainable. In other words, social inclusion and environmental sustainability must be added to the generation of economic profits. Although this opened up new opportunities, it also contributed to further complicate the reality in which STI policies should play a role.

Indeed, today these policies must respond to multiple challenges, while they also reflect different problems and historical moments. In an ideal world, it is desirable to understand the differences, and to coordinate the different policies, so that they generate positive feedbacks and synergies.

What happened to our countries in this scenario? Between the end of the 1950s and the beginning of the 1970s, public organizations were consolidated to carry out science policies. In other words, the countries began to walk a path of building their scientific systems. In some cases, these systems were developed successfully, in others they remained embryonic, in several cases they were interrupted. The new challenges of promoting technology policy and, later, innovation policy, were added on top of that first effort, with the institutional framework that had been conceived and designed for that purpose. Certainly, the agencies and instruments to carry out the policies were modified and adapted over time but based on what had been originally designed to respond to the need to create new scientific knowledge. Such accumulation of institutions generated a final result that did not necessarily respond to the ideal that had been planned.

The reality, as it is well known, did not remain stable, but rather became more complex in an inertia of accelerating change, which resulted in public institutions often arriving late to the proposed objective, as in Zeno's paradox, in the race of Achilles against the tortoise. Yet in this case it appears that it is the tortoise that tries to catch up Achilles.

Faced with this complex reality of accelerated change and an institutional framework still in the making, my main recommendation is to go back to the sources, simplify the analysis, clarify variables,

and only from there further the complexity of policies. Turbulent times, of great changes at unknown speeds, demand firm and stable steps.

Therefore, it is important to understand once again why we need to develop a scientific system, and what policies are necessary for this purpose. We need to think deeply what type of technological development our society's problems require, and design policies that allow us to import, adopt, adapt and generate these technologies. We need to see how to address coherently both issues -science and technology policies- and, at the same time, establish government dynamics that stimulate the innovation models that are desirable for our societies. This necessarily requires us to rethink our institutional framework and re-generate it in an agile and innovative way, without the fear of applying Schumpeterian creative destruction also in the management of public affairs, designing new tools, risking trial and error, and sustaining the necessary bases to ensure this process: professionalism, sustainability and continuous learning dynamics.

Frederico Rocha

Can Technology Provide the Answers We Need?

Cassandra was certainly one of the most intriguing characters of Greek mythology. She was able to predict the future, given by Apollo. Nonetheless, no one believed her predictions. In the 1970's economists began the discussion on the limits of growth due to environmental issues. This discussion probably began with Georgescu-Roegan's arguments on entropy (Georgescu-Roegan, 1971). Using the laws of thermodynamics, he argues that the use of natural resources in economic development is a continuous transformation of low entropy into high entropy, that is, a transformation into waste. This argument is reproduced by Dale (1979) in a debate with Stiglitz (1979). Dale argues that the Earth is a closed system, thus subjected to entropy. Its only open window is the sun's energy, the only true renewable energy. Thus, we should limit ourselves to the use of solar energy. His solution to the problem was however quite bitter. He proposed the creation of three institutions, one to limit population growth, another one to limit consumption (actually, the stock of artifacts) and a third one to limit inequality.

Thus, an alternative approach to the subject by then seemed more sympathetic. Stiglitz (1979), initially, looks at history, and claims that the limits to growth are due to the scarcity of natural resources in an old Malthusian argument. He then draws a number of tools used by economists, such as the technical rate of substitution, the rate of resource-augmenting technical progress and the elasticity of demand to argue that:

“... if resource pessimists are correct ... they must convincingly show that (1) ... the elasticity of substitution is low ..., (2) the prospects of adapting tastes to the new set of economic circumstances are poor; and (3) the prospects are bleak for technical changes that would enable us to use better what resources we have” (Stiglitz 1979:47).

Furthermore, he shows a strong belief that markets will not overestimate available supplies and underestimate future demands. The answer therefore is quite simple: natural resources problems should be overcome by the price system and by technical progress. To be so, it should be enough that the product elasticity of product to capital is greater than the product elasticity of product to natural resources.

The invisible hand solution proposed by Stiglitz had results that can be clearly examined after 40 years. The unbounded Prometheus had astonishing results. From 1980 to 2017, the world decreased the CO₂ intensity of the GDP by 1.8% a year, that is, a unit of product today costs 50% less in carbon than it used to cost in 1980 (Nordhaus 2019).

However great has been the world's increase in carbon efficiency, carbon emissions continued to grow over time, and, during the same period, they almost doubled. Thus, technical progress is clearly not enough. Nordhaus holds that the reason for the increase in carbon emissions is its public goods characteristics. Carbon emissions controls are open to free-riding, and free-riding has dominated the matter up so far.⁵

One way to overcome the problem could be to charge a Pigouvian tax on carbon emissions. According to Nordhaus (2019), to maintain temperature increases below 2 degrees centigrade, the social cost of carbon should vary between US\$158 and US\$279. This is equivalent to charging twice Brazil's or Spain's GDP a year in carbon taxes, which should be unattainable in a world that has seen little advances after many climate agreements.

To make things worse, emissions are very poorly distributed across the population and tend to accompany wealth. The most intense emitters are also the richest. The top 1% emitters are responsible for 17% of total emissions and the top 10% emit 50% of total emissions. Thus, emission cuts should be concentrated on higher emitters.

It seems that technical progress has given some important answers to mankind's need to overcome global warming. We have been very successful in substituting renewable energy generation for fuel energy sources. Many of our production processes have become less energy intensive. Nonetheless, the need for energy has increased. We live in warmer houses during winter and cooler ones during summer. Air conditioning seems to be of higher need after global warming. People travel more and world's mobility has increased thanks to the use of energy. We greatly depend on individual transportation solutions due to our individuality and some of the solutions searched by technical progress do not overcome this trajectory. For instance, motor vehicle industries are looking forward to electrical automobiles.

The solution for our problems will need important shifts in rationality, behavior, and institutions. It does not suffice to use technical progress; the world should pose the need for the use of new technological trajectories and paradigms (Dosi 1982).

Cassandra prophesied that Paris would burn Troy into flames. The prophecy came true due to Paris' election of Aphrodite as the most beautiful goddess. Paris chose Aphrodite over Palas Atena and Hera due to bribery. Palas Atena offered the victory in all battles, Hera promised Eurasia. However, Paris did not know he was a prince for he was raised as a shepherd. So, he chose the love of the most beautiful woman in the world. It was an easy choice for Eurasia and heroism was of no use to a shepherd. It was thus a choice due to ignorance. Denialism is a substitute for ignorance for it justifies bad choices. We should not repeat the mistakes and change our paradigms.

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Florenca Barletta

STI policy at the service of development must consider territorial imbalances in its design and implementation.

With each technological revolution, the world is divided between a few leading countries, a few followers, and many more laggards. The current paradigm of sustainability and 4.0 technologies is no exception.

In this world, Latin American countries belong to the "club of peripherals" and the gaps are widening, with the developed world but also between and within the countries of the region (UNIDO, 2020). This situation is not new either. Already in the middle of the 20th century, the classical school of economic development provided the explanation of how international gaps are reproduced within national territories, generating unbalanced regional growth based on processes of cumulative causation (Young, 1928; Myrdal, 1968; Kaldor, 1972). More recently, evolutionary economic geography has contributed to the explanation of these processes based on the notions of path-dependence *and* place-dependence (Boschma & Martin, 2010; Boschma & Frenken, 2018). The productive and technological dynamics of territories are inertial – patterns tend to be reproduced over time – and idiosyncratic – they depend on the characteristics of each territory. This unbalanced growth has led to the deepening of territorial gaps that manifest themselves in multiple dimensions: poverty, technology, education, gender, connectivity, health, production.

Faced with this scenario, we ask ourselves: what contribution can STI policy make?

The first answer is "don't keep doing the same thing." In the last 30 years, at least in Argentina, different STI policy instruments have been tested with the same results: low innovation rates, low participation of the private sector in total R&D spending and deepening of external and internal gaps in productivity and per capita output. At best, STI policy ends up functioning as a static allocation mechanism. Resource allocation schemes are optimal from the point of view of the skills and technological knowledge existing in a small number of companies that are territorially and sectorally concentrated. However, it is not this static allocative efficiency scheme that leads to widespread increases in innovation and productivity. Implemented in this way, STI policy is not equalizing, but rather sustains existing asymmetries and inequalities. Most of the resources end up being allocated to a small portion of companies, with high technological capabilities and concentrated by sector and geography.

STI policy can be equalizing and contribute to development if it is used to that end. In other words, STI policy does not have to be an end but a means to an end: development.

To this end, an STI policy at the service of development must consider territorial imbalances in its design and implementation. Latin American countries are not homogeneous, within them different generations of technology and layers of technological revolutions coexist and determine different starting points. Thinking about STI policy from and for the different realities belonging to the same national territory within the framework of the current paradigm of sustainability and 4.0 technologies requires considering all the possible windows of opportunity, and not importing agendas and slogans uncritically.

For example, Argentina is one of the countries that produces the least carbon dioxide emissions. What's more, in the balance between emissions and carbon capture, Argentina is in an excellent position in the world. Moreover, the territories that lag behind present the best conditions for sustainable development, given the diverse aptitudes of their soils, the advantages of climate, biodiversity, the availability of fresh water, among others. In these territories, windows of opportunity can be found in alternative energy generation sources, in the financing of development based on carbon credits and in the adoption of 4.0 technologies to improve access to basic services. In contrast, modern Argentina offers a different picture, with advanced biotechnology and software, and the level of technological capabilities close to the international frontier.

Therefore, the windows of opportunity are not the same for every Argentina, and the insertion in the current paradigm must be idiosyncratic. In this context, what national innovation system can contribute to an equalizing STI policy?

On the one hand, a modern and flexible national system is needed. Argentina has an institutional system that was created in the mid-20th century for the missions of the time, when it was pursuing nuclear energy and a dual productive model prevailed, with remarkable differences between the countryside and the industrial regions. Today the world is very different and changes at an increasingly rapid pace, and it is important to reflect on how the scientific-technological system adapts to these changes.

On the other hand, greater openness of the system is required. National challenges, priorities and missions are now part of all STI plans and legitimize STI at the service of social problems. Sometimes, STI can solve problems that do not originate exclusively in STI. However, inequality and many other country's challenges cannot be solved by technological change. Many barriers are not technological, but rather economic, social, infrastructural. Moreover, many technological barriers are not linked to 4th generation technologies but to technologies of the second industrial revolution. If we want to think about STI policy for development, we need to think about the coherence with other policies and spheres of government. To this aim, a coherent STI system is not enough, and we also need a system that is open and ready to improve its coherence.

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Olman Segura Bonilla

The fifth industrial revolution must represent the great leap forward that the humanity takes towards a cleaner, fairer, more equitable and healthier development

In the current context, after going through the COVID-19 pandemic that has impacted our societies like never before, it is important to review the challenges facing the dominant economic development model and the windows of opportunity that we could take advantage from to make a shift towards more inclusive and sustainable development.

The current development model of our countries is mainly focused on the goal of economic growth. In this sense, it is important to insist that economic growth is not the same as development. The first alludes to a merely material and monetary process, through which the levels of production and economic activity increase, generating greater pecuniary wealth for the territories, but without sufficiently addressing the issues of distribution of benefits and environmental impacts. Development, contrary to growth, is a more qualitative than quantitative process, through which a transformation of the existing economic structures occurs, to satisfy the needs of the people and ensure their general well-being, which includes social and environmental issues (Marquéz and others, 2019). In addition, the development to which we should aspire must consider that our planet must support the activities of the present generations and those that have not been born yet.

The advantages derived from the logic of economic growth linked to the model of linear development, extraction, use and disposal of resources, are obvious; however, the social and environmental impacts they produce are hidden and concealed in the system. Until a few decades ago, the claims regarding the loss of biodiversity, the incapacity of ecosystem resilience, global warming, and other problems, did not seem to be economic problems, but were basically relegated to environmental groups. The situation has radically changed, and humanity is currently witnessing one of the most notorious, evident and scientifically proven impacts, the product of anthropogenic actions mainly linked to the use of fossil fuels, which is climate change. This affects the entire economy, producing variations in people's production and consumption patterns and modifying the behavior of all actors in our society.

Although it is true that economic growth has a necessary impact to achieve the development of a territory, this is not the only condition, nor is it sufficient, since "income is not the sum total of human life" (Labrunée, 2018). There are other factors such as health, education, the environment, that influence the well-being of populations. Formally, the United Nations Organization [UN], establishes that development refers to a "qualitative increase of countries or regions in the improvement of social conditions", and that this happens when a nation or territory is capable of creating the necessary means to promote and maintain the prosperity of its inhabitants. Hence, it can be inferred that to achieve technological capabilities for an inclusive and sustainable development, as stated by Aboites

and Dutrénit (2003), "public policies associated with science and technology must be guided by a strategic vision of the role of technology in economic and social development...".

Technological capabilities, as part of the knowledge economy, as well as the proper functioning of national innovation systems, continue to be very limited in our countries, and must be strengthened to transform the development model. Each country has innovation systems - which include key factors such as technological capabilities, investment in research and development, the national education system, science and technology policies, and the associated institutional framework - but much needs to be strengthened to leave the dysfunctional state of these systems. The institutional burden of centuries of doing things with a certain logic that did not take into account that the economic system is sustained by the ecological system from which inputs are extracted and waste is discharged represents a heavy legacy. This logic must evolve with the new "learning economy" that modifies the current institutional framework to promote the circular economy that cares much more about sustainability and social inclusion.

The knowledge economy that places the generation of innovations, in many cases linked to technological transformation, as a central element, must also be capable of promoting green innovation and circular economy. Following Lema and Rabellotti (2023), the imperative of a green transformation leads to new consumption patterns that can reduce the environmental footprint of production and trade, using more environmentally friendly goods and services, which must be transmitted through Global Value Chains.

At present, different innovative initiatives are being developed towards the green transformation, through changes in the techno-economic paradigm, and in the institutional, market and technological domains. This has led to the opening of new windows of opportunity, for a new style of development, much more sustainable, which should be taken advantage of and promoted by the territories. Green windows of opportunity are defined as favorable conditions for development, which are usually originated and promoted through public actions and are influenced by demand conditions and technological changes (Lema and others, 2020). Green windows of opportunity can arise from an institutional change, which generates a new demand in the market, and then encourages technological innovation, as is the case with renewable energies (Hansen and Hansen, 2020, as cited in Lema et al., 2020).

The countries' innovation systems evolve little by little because of the learning that occurs in the educational system and in daily production processes. In this sense, universities are strategic instances to generate research and new knowledge and to systematize learning processes, but also, to form part of inter-institutional alliances for development. The Triple Helix model, which considers a close and constant interaction between universities, the government and the business sector, is an approach of great value for the development of strategic development policies. This implies that the responsibility for innovation and development does not rest only on one of the three sectors, but all three should maintain a good functioning and a good quality of interactions.

The historical moment in which we find ourselves is unique and perhaps decisive in promoting the foundations for the fifth industrial revolution. The great progress that global technological development is having, the rapid dissemination of the use of information and communication technologies, the Internet of Things, robotization, artificial intelligence, machine learning and many other phenomena must be taken advantage of. This progress should not only be directed to innovate in the creation of products and services that are of great interest to economic growth, but also to generate eco-innovations, for example for mitigation and adaptation solutions to climate change, to promote the circular economy and to promote more equitable distribution of benefits and reduction of environmental impacts.

Inclusion and sustainability should be part of the Fifth industrial revolution. New technological advances must be compatible with greater employment and job opportunities, and with the reduction of negative environmental impacts, that are consistent with economic development. The fifth industrial revolution must represent the great leap forward that the humanity takes towards a cleaner, fairer, more equitable and healthier economic development model.

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