

Knowledge generation and capability building in Latin America and the Caribbean: challenges for productive incorporation of new digital technologies

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Introduction

This article forms part of studies focused on new technical and production processes (grouped in the category of Industry 4.0), in light of strategies that emerging and developed nations have implemented to encourage growth in manufacturing and society. The questions analyzed here refer to the model's continuity. Special emphasis is placed on issues involving new challenges in the world's increasingly complex geopolitical scenario. Russian's invasion of Ukraine has revealed alterations that constantly confront the global economy. The geopolitical consequences for industrialized nations will exert weight on the future of digitalization as well as the conformation of political alliances.

The speed of technological changes represents multiple challenges for public policies, especially in industrial, technological, and educational policies. Assumptions involve the creation of flexible platforms, regulation, supervision, and technological abilities to renew the system of production, where small to mid-sized enterprises (SMEs) play an important role and cannot be excluded from the benefits. It is a situation in which talent is a rare asset, and international competition turns to high salaries and online work that facilitates personal and professional activities both locally and abroad. In this respect, strategies must be implemented to develop and improve human capital. The setting assumes opportunity and new challenges for regaining talent, supporting the formation of abilities in society, and promoting links among industry, public policy, and academia. The purpose of such links is to coordinate efforts to transform the behaviors and knowledge needed for establishing concrete projects in response to the transformations of innovation and digitalization.

1. Challenges posed by growing digitalization in the economy and society

All nations, firms, and markets are potentially affected by digital transformation. But not all countries innovate in the same way, nor do they have the infrastructure and social consensus to generate trust and information for individuals and organizations in managing the risks of digital privacy and security. The expansion of digital industrialization has revealed that its development not only deals with technical advances, but also involves the coordinated action of government policies and markets. The documentation of nations' empirical experience in using digital technologies has permitted access and evaluation of favorable conditions for its use, in terms of communication infrastructure, services, and data as well as new regulations and equilibriums in the employment and improvement of technical abilities. It also refers to the challenges of secure information, reliability, and integration, which have become the primary bottlenecks for designing and processing the productive integration of Industry 4.0.

Studies completed in industrialized and emerging nations (Argentina, Brazil, and Mexico) have made progress in conceptualizing the new model's complexity, emphasizing changes in the sociotechnical paradigm and the forms of tentative governance for ensuring changes: interinstitutional arrangements and coordination between public and private-sector actors (Motta et. al, 2019; Carmona et. al, 2020; Maggi et. al 2020; Casalet y Stezano, 2021).

The intensity of interinstitutional coordination for developing the Industry 4.0 model is related to nations' history of production as well as the efficiency of communications among institutions and actors in disseminating policies. Industrialized nations with more consolidated dialogue among actors have articulated hybrid and formal institutional arrangements for orienting bridge strategies in the analog-to-digital transition, creating institutions, multi-actor platforms for information, the expanded use of advanced technologies, and interinstitutional collaboration to reduce obstacles and conflicts in application. In the middle years of this century's first decade, most developed LAC nations began to show concern about the future of advanced technologies in the export industry, in academic discussions, and in the design of industrial policy agendas and STI.

2- Public policy responses

The search for information on international experiences led to a network of exchanges among OEMs, clusters, business chambers, and technological centers to systematize the achievements of programs that launched the Industry 4.0 model in firms, industrial policies, educational policies, and diffusion prepared by developed nations. .

Faced with the new challenges of changed paradigms in industrialization strategies—based on the growing weight of new digital technologies in production—national governments have developed multiple strategies that combine measures of industrial policy, scientific/technological policy, and innovation. The rhythms and strategies of adopting national measures have been different in industrialized and emerging nations. In many cases, due to the absence of a clear definition of the medium- and long-term vision of economic development and industrial policy, emerging nations design supports for the development of new technologies and their productive incorporation in an interrupted manner. In contrast, industrialized nations have articulated national strategies along with a planning perspective of productive and economic development in which the main emphasis has been on the training and development of the organization's capacities and talents, its employees, and associations in the public and private sectors.

In a pioneering way, Germany developed its project entitled Industry 4.0 since 2006 with strong public-private support. From a governance perspective a broad alliance between industry and government, with a very active participation of specialized SMEs (Schroeder,2017). Since 2011, in the United States the Plan for Advanced Manufacturing Development is instituted: a coordinated action of information, automation and software development actively linking government, industry and academia (NSTC, 2012). More recently, the Chips for America Act and The Inflation Reduction Act centralize research and control in the USA on research and advanced technologies. With strong inspiration from the German I4.0 model, China has sought, from a state-dominated standardization system, to expand dominance in artificial intelligence and 5G networks. Similarly, it has made an active investment in the manufacturing and robotics industry, pursuing efficiency in manufacturing, the promotion of Chinese brands, green manufacturing. The results obtained by the so-called

Made in China 2025 Plan have yielded positive results in terms of increased scientific publications and patent registration and breakthroughs in the fields of 5G, electronic cars and solar panels (Li, 2018).

Industrial policies show common tendencies in all industrialized nations: (i) their articulation of a national nature, associated with a vision of economic development; (ii) emphasis on productive digitalization promoted by the development of capacities; and (iii) an orientation to develop new organizational forms of a public- and private-sector nature to underline the role of training workers and companies to adopt new digital technologies.

Policies of industrial and technological development are differentiated by national production goals, the type of geopolitical positioning associated with aspired industrial and development, and the expected role of new digital technologies at the level of production and society. Thus, while the production and technological policies of the United States and China have the final objective of promoting their technological leadership around the globe, in the European Union, the security and regulation of new technologies is a central challenge in the framework of global tension, in defining new norms of standardization and regulation. Nations seek to reinforce competitiveness through industrial policies that ensure access to advanced technology beyond digitalization. On the other hand, the private sector and the nation are required to face new risks to develop this model, to maintain speed and experimentation, and to generate institutional supports and regulation that allow greater independence in the world's technological bottlenecks.

Conclusion

A fundamental task in the productive incorporation processes of new technologies in LAC is the generation of knowledge from research on the tendencies of digitalization processes and their emerging changes. Furthering knowledge is especially key in: (i) the direct effects of new technological and production tendencies on company capacities; (ii) skills in SMEs and suppliers in the use of these new technologies; and (iii) companies' possible insertion strategies in the general conditions of sale.

A key dilemma for development in Latin America and the Caribbean lies in the formulation of national and regionally coordinated strategies that promote digital transformation processes, particularly by identifying and taking advantage of new technological niches. For LAC, STEM skills and competencies must be positioned as the key factor for technological advancement and cutting-edge research in productive development, driving innovation dynamics from quality research. Data availability is another major shortcoming in LAC: the inability to process and store huge amounts of data has been one of the main drivers of R&D that have boosted the activity of basic artificial intelligence algorithms from deep learning strategies and by reinforcement are not common in LAC. Latin American firms lack these inputs for decision-making processes, and there are no strategies for researchers to access the data generated. Venture capital as a financing scheme for companies focused on the development of new digital technologies has also assumed a minor role.

The current situation (even before the COVID-19 pandemic) shows that if changes are not made to the region's productive structures, they will be characterized by a gradual process of high productive heterogeneity and a widening technological gap, in comparison with developed nations.

In LAC, promoting processes of inclusive digital transformation will favor strategies of change in the rhythms of technological adoption in the region. These processes require a focus on equal access to high-speed Internet and the existence of digital competencies, ethical data management, and the development of digitally secure infrastructure that facilitates technological adoption. LAC require the reinforcement of capacities based on the training of human resources, with an emphasis on creativity in the use of new technologies. The challenges associated with the use of new digital technologies require a series of technical skills, as well as more behavioral and cognitive abilities, such as creative thinking and communication.

This type of reorientation requires public policies to adjust competencies in education and business, especially those based on tools to control and predict the needs of certification. Development of education and professional training through learning and dual training would permit improved alignment of student skills with the changing demands of

technological progress. This process could include certain measures that the European Union has adopted in recent years, including the promotion of dual training, company participation in the design of plans of study, expanded learning, new types of learning adapted to the needs of the job market, and further attention to the certification component of learning (Goos et al., 2019).

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