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Digitalization, expectations, and industrial dynamism: a conceptual map

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ABSTRACT

This paper proposes a conceptual, theoretical and analytical map, aiming to help understand the contemporary process of digitization of industrial companies in developing economies. It examines the relevance of the Schumpeterian hypothesis that technical progress in the digital age can drive a 4^{th} long cycle of industrial dynamism or the 4th Industrial Revolution. It also highlights the complementarity of this hypothesis with the Keynesian view of the business calculation of the rate of return on investment in innovation under uncertainty, changing expectations, and conventions, pointing out the key role of the entrepreneurial drive (animal spirits) in capitalist development. The paper also analyzes the growing challenges that the digital age poses to developing countries, based on the structuralist and institutionalist views of Furtado and Abramovitz, respectively. Finally, it warns of the risk of deepening heterogeneities, inequalities and, at the limit, exclusion of such countries and their enterprises from the 4th IR.

KEYWORDS | Industrial digitalization; Catching up; 4th Industrial Revolution; Expectations; Heterogeneity; Social capability

1. Introduction

This article presents a conceptual map to analyze the contemporary process of *catching up* and digitizing industrial companies in peripheral countries. It seeks to offer a theoretical-analytical reference to the challenge of analysis, formulation of hypotheses, and research.

Three theoretical axes inspire this reference, comprising the following questions: a) *the role of technical progress in cycles of economic expansion*, based on Schumpeter and Schumpeterian literature; b) *the formation of conventions and the role of expectations in business investment and innovation decisions*, based on Keynes and Keynesian authors; and c) *the implications of social empowerment and structural heterogeneity on the possibilities of catching up in developing economies*, derived from structuralist theories, especially Celso Furtado's ECLAC and Moses Abramovitz's historical-institutionalist view. These three analytical questions and respective theoretical aspects will be the object of sections 2, 3, and 4 of this paper.

In line with the historical-theoretical and holistic view of these great thinkers, the following spheres of analysis will be considered: a) at the macro (countries, societies, and macro policies), meso (market structures, sectors, regions, and meso policies), and micro levels (companies, entrepreneurs and their expectations, strategies, and business models); and b) the following cross-cutting themes: environment and innovation ecosystems, reorganization of global value chains, R&D practice, participation in exports, training, profile and qualification of workers.

The objective of the paper is modest: extract from the three theoretical axes presented here in a stylized way, without the pretense of originality, analytical frameworks that allow integrating, comparing, and translating the views of these great thinkers in a useful way for reflecting on the contemporary challenges of *catching up* of developing countries, including their industrial digitalization processes[1].

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[1] The option was to focus on the analytical integration between the original approaches of Schumpeter, Keynes, Furtado, and Abramovitz, without worrying about a comprehensive and exhaustive review of the rich literature of the respective followers and interpreters, also because this task would demand a cyclopean and meticulous effort.

Reflection on this analytical-conceptual map began in 2017 during the elaboration of the *Indústria 2027* project (INSTITUTO EUVALDO LODI, 2018), contracted by the National Confederation of Industry (CNI) to the Institute of Economic of UFRJ and the Institute of Economics of UNICAMP, which also included researchers from the Fluminense Federal University (UFF)[2]. By inaugurating an investigation into industrial digitalization in Brazil and in developing countries, such a project required the construction of a standard theoretical reference capable of providing consistency and conceptual clarity to the preparation of its reports.

It is Paramount to emphasize that this reference or conceptual map, at a holistic and abstract level, intends to fulfill only some of the methodological requirements necessary for the works of the UFRJ-UNICAMP Group presented in this edition of RBI. Other contributions, notably that of Prof. João Carlos Ferraz, offer analytical categories, dimensions, and variables that are relevant and essential to the specification of working hypotheses, notably for quantitative research.

In 2019/2020, the same group led by UFRJ and UNICAMP researchers funded the *Indústria-2030* project to carry out a new field survey contracted to Vox Populi, which obtained responses from around 1,000 Brazilian industrial companies of different sizes and sectors, generating a new set of information that made it possible to advance the initial research program.

Among the desired advances, we seek to elucidate the constraints and understand the business strategies for adopting contemporary digital technologies based on the observations collected by the field surveys in 2017 and 2020 - surveys that are self-declaratory on the perception of

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[2] Over the course of two years of the I-2027 project, the author wishes to highlight that the collective reflection had the structuring, insightful, and luminous contributions of the late professor David Kupfer and other members of the coordination committee, which have been incorporated in this article.

executives regarding the current situation and perspectives (expected or planned) for advancing digitalization in the respective companies[3].

The systematization of this theoretical-analytical framework aims at the continuity of the present research program and the advancement of reflection on the challenges of *catching up* and digitizing the industry in developing countries and Brazil.

2. A Schumpeterian (and neo-Shumpeterian) reading of technical progress in the current stage of digitalization

The understanding of technical progress as an autonomous driving force of the dynamism of capitalist economies was pioneered by Joseph Schumpeter in his masterful *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalisty Process* (SCHUMPETER, 1939). The issue in focus here is to what extent the current digital technologies could drive a 4th long cycle of innovation and expansion.

At the outset, in Chapter II of *Business Cycles*, Schumpeter warns that "stationary equilibrium" is a useful abstraction only for understanding the matrix of relationships between sectors (by large categories of demand) in a market economy. It is, however, a foreign concept to the development of capitalism where the constant competition for corporate profit - combining technical progress with the creation of credit by the banking system - obligatorily induces fluctuations and endogenous economic cycles.

Drawing on the work of the Russian economist Nikolai Kondratieff (1926), Schumpeter deepened in *Business Cycles* the theoretical analysis

[3] The first methodological challenge of the I-2027 project was to define the evolution of digitalization paradigms in industrial processes from the 1950s to the end of the 2nd decade of the 21st century, characterized under four categories of factory automation: G1 (sparse, punctual and rigid automation), G2 (partial automation of lines or parts of production processes); G3 (integrated automation of the plant and company management), G4 (integrated automation, connected online and intelligent production and management of the company and its value chain).

of long waves (from 40 to 60 years) under the hypothesis that technical progress is an autonomous dynamic force, capable of sustaining an expansionist tendency over several decades. In his theoretical analysis of capitalist evolution, Schumpeter postulates a simultaneous scheme of three cycles: the long ones (Kondratieffs), the ten-year cycles (Juglars), and the short ones (40 months, or Kitchins). In the Schumpeterian view, long waves are triggered by innovation clusters with three requirements: capacity for self-feeding, that is, creation of new processes and products over a long period; thrust power, in the sense of articulating, through input-output relations, downstream and upstream sectors capable of multiplying employment and income to feed back the creation of markets; and ability to recover, in the face of the eventual exhaustion of medium-term cycles, reinvent processes/products and revitalize the creation of markets and jobs to lead recovery[4]. Thus, the neo-Shumpeterian interpretation of the tendency of industrial capitalism since its deceleration in the 1970s of the last century transits through the premise of the exhaustion of the dynamism of the 3rd Kondratieff, combined or not with other hypotheses[5].

Therefore, in light of the hypothesis of secular stagnation, it is worth assessing whether or not the current characteristics of technical

4 In his historical analysis of capitalist evolution since the industrial revolution, Schumpeter periodized three long cycles: the first Kondratieff was born in the 1780s and lasted until 1842, corresponding to the 1st industrial revolution that gave rise to capitalism (iron foundry and forging and "machinization" of textile manufacturing); the second cycle comprises the period from 1843 to 1897 (the Kodratieff of steel and the steam engine) and the third long cycle begins in 1898 and was ongoing at the time when the author was writing the Business Cycles (the 3rd Kondratieff, of electricity, chemistry and internal combustion engines).

5 In the view of the French Marxist-regulationist school of Michel Agglieta (1974), the Schumpeterian hypothesis of a loss of technological dynamism from the 1970s onwards is mixed with the analysis of the exhaustion of Fordism as a dynamic period of strong expansion of mass consumption combined with mass production at falling costs, made possible by the relevant process innovations introduced by the assembly line in the automobile industry. Another neo-Schumpeterian interpretation, which highlights the extraordinary nature of the third long cycle and its exhaustion, was proposed by economist Robert J. Gordon (2016), giving rise to the hypothesis of secular stagnation in the future.

progress, marked by the genesis, maturation, and increasing penetration of information and communication technologies - ICTs, have the power to drive a 4th long cycle of expansion of industrial accumulation, induced by widespread digitalization. Indeed, the expansion and accelerated dissemination of information technologies since the mid-1970s of the 20th century, under the strong and continued impulse of Moore's "law"[6], points to a positive answer to this question. After five decades of dissemination of computers and other devices, with exponential expansion of their computational capabilities, massification of access to mobile telecommunications (sequence of generations 2G, 3G, 4G), and notably, from the mid-1990s, the accelerated dissemination of access to the Internet, the conditions seem ripe for a long cycle propelled by the comprehensive digitalization of production systems and societies.

In sum, the rapid evolution of ICTs in the 1970s, 1980s, and 1990s (the ICT Age) developed the technical conditions for widespread and integrated digitalization online and engendered the emergence of the "Digital Age" in the first decades of the 21st century[7]. In this sense, "digital technologies" can be defined as integrated online to the Internet, widely applicable (hence pervasive), connected and intelligent advanced stage of ICTs.

Several developments, including the increase in miniaturized and distributed computational capacity in devices with radio frequency identification (RFID), high-performance supercomputers, the tremendous expansion of the Internet and personal connectivity through the massification of increasingly powerful smartphones endowed with

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[6] Derived from an observation by the chemist and director of INTEL Gordon E. Moore (1965), the law postulates that the ability to double the number of transistors on silicon chips would allow for the square of computing power. Initially, he predicted that these exponential jumps could occur annually; then realistically adjusted its projection to a period between 18 and 24 months (ROTMAN, 2020).

[7] According to the International Telecommunication Union (2020), total Internet users jumped from 5% of the world's population in 1999 to 51% in 2019 (from 280 million to 4.0 billion people) portraying its extraordinary expansion, especially in developed countries where the % of users covers 86% of the population, in contrast to developing countries where it reaches 47%. Expert consultants project that the global reach of the Internet will surpass 2/3 of the world's population in 2030.

global positioning system (GPS), "cloud" computing, big data analytics, machine learning, and artificial intelligence, the emergence of the 5G telecommunications standard, the advancement of the Internet of Things (IoT) and manufacturing 4.0, build on and at the same time place in evidence an *articulated core of digital technologies with strong inductive-transforming power*.

The current wave of technological innovations - known as the 4th Industrial Revolution - is indeed notable for the significant convergence and synergy between technical innovations and between fields of scientific and technological knowledge that were until then relatively distant, and also for the cooperative participation of many actors (companies, ICTs, universities), increasingly on open innovation platforms. It should be noted that these advanced digital technologies are key to combine different actors and scientific and technical bases in order to solve hitherto invincible technological challenges. For example, DNA sequencing and editing only became accessible as a result of the combination of genomics and high-performance computing, with increasing power and declining costs. Self-driving vehicles are being made possible by robotics combined with intelligent software and specialized processors in image recognition with 5G connectivity. Machine learning technology derives from the ability to analyze large volumes of data based on specialized processors.

Understanding the synergies described above makes it possible to underline, not exhaustively, certain striking features of technical progress in the current and future stage, namely: the multidisciplinary nature (in the scientific and technological spheres), convergent (through the combination and integration of technology *clusters*), multi-actors (under open, internationalized innovation ecosystems, which bring together academia-technology centers-companies), and pervasive, due to the wide applicability of digital technologies in all stages of the innovation cycle and the broad connectivity between institutions, companies and users in all economic activities, in particular in industry and associated services, at the micro and meso economic levels.

At the microeconomic level, the transition from the 'ICT Era' to the 'Digital Era' implied the tendency to transform the company into a network in which all its functions and management are integrated *online* under 4.0 systems, that is, under Manufacturing Execution Systems (MES) and Enterprise Resources Planning (ERPs). Online integration demands and results in profound qualitative, functional, and cultural change in companies. As a specific example, illustrative of this comprehensive transformation, the former IT or ICT departments whose role was to provide support to the circumscribed use of information technologies, lost their *raison d'être* in the face of the ubiquitous, integrated, and functional digitalization of production and management processes that encompass everything – supply chain, stocks, factory operation, logistics, commercial chain, customer relationship, in addition to the classic business management functions, such as payroll and HR, finance, accounting, taxes, and government relationship.

At the macro level, it is worth noting that the exponential and sustained increase in the power of digital technologies, concomitantly with the sharp reduction in their prices/costs ('Moore's law'), functioned as the classic Schumpeterian factor propelling the wave of combined, integrated, and cooperative multidisciplinary innovation development of the last two decades – with strong economic and social impacts. Therefore, facing the discussion about the end of Moore's "law" is relevant[8], as analyzed by Rotman (2020), since sustaining a 4th long cycle would depend on the persistence of this autonomous driving force.

[8] The ability to 'pack' smaller transistors into increasingly dense chips demanded lithographic methods and increasingly sophisticated equipment, which reduced the distances between transistors below 100 nanometers over the last 20 years. In the most advanced chips, the dimensions are currently between seven and 10 nanometers. This advance demanded more complex and expensive facilities (a factory at the technological frontier currently costs around US$16 to 20 billion) and slowed down Moore's "law" - with the "leaps" between new generations spaced every four to five years (no longer every two years). The "law" has already been significantly affected, incurring increasing marginal costs, which has narrowed down to just three companies capable of manufacturing the five-nanometer generation. In 2010 there were eight in the frontier dispute; in 2002, about 25 (ROTMAN, 2020).

On the other hand, as Rotman (2020) points out, several factors can counterbalance the deceleration of 'Moore's law' and giving technical dynamism na extended survival. One of them is the strong synergy between large systems and connected platforms, driven by the continued expansion of the Internet and high-power digital telecommunications networks (5G and later 6G). By bringing distributed computational capacity to the cloud (IoT, manufacturing 4.0, society 5.0), such a synergy tends to generate efficiency gains and create new services and markets. Another factor is the great potential for advancing chips specialized in specific applications (such as Graphics Processing Units - GPUs), capable of unraveling Big Data in parallel processing, with more speed and lower energy consumption, generating new services based on AI. In addition, new processes may increase the number of transistors on chips, by reducing the size of transistors and/or using 3D architectures (by superimposing interconnected layers). Finally, improved software will maximize the speed and power of the most complex universal processors (CPUs) (which have several processing cores), multiplying the productivity of current generations of *hardware*.

The market trend in favor of specialized chips (especially for uses that involve large scales, more speed, and energy savings), combined with the slowdown in the advancement of universal processing chips, inspires concern insofar as it will weaken the computer as a technology of general use (THOMPSON; SPANUTH, 2021). While 'Moore's law' lasted, the exponential improvement of universal processors benefited all users. On the other hand, investments in specialized chips selectively aim at boosting specific businesses that are profitable enough to pay back the investments. For example, Google, Microsoft, and Baidu are investing heavily in developing dedicated AI chips to meet their needs and bolster their competitive advantages. In this sense, several experts have warned about the need for a public policy to encourage new solutions to reinvigorate the advancement of universal processors at reasonable costs. (THOMPSON; SPANUTH, 2021; KHAN; HOUNSHELL; FUCHS, 2018).

However, policies to promote microelectronics are not new and rely on creating positive externalities for the economy as a whole. In order to not lose ground, advanced industrial countries have been adopting long-term strategies aimed at mastering the frontiers of innovation and strengthening the competitiveness of their industrial complexes and services. Since the middle of the 2010s, the United States, Germany, South Korea, China, France, Japan, the United Kingdom, and a dozen other countries have launched ambitious industrial strategies centered on robust science, technology, and innovation programs (see INSTITUTO EUVALDO LODI, 2018, chap. 9, for a compilation of plans and documents on advanced manufacturing and digitalization).

The violent and unforeseen impact of the Covid-19 pandemic in 2020-2021 led industrial countries to revisit those strategies and set new priorities, such as health security with requalification of their health ecosystems, environmental sustainability with bold decarbonization targets, accelerating advances in artificial intelligence, high-performance computing, and semiconductors. Among these revisited strategies, we highlight, for example, the United States Innovation and Competition Act (UNITED STATES OF AMERICA, 2021) and the CHIPS Act of 2022, China's 14th Five Year Plan (2021-2025) (CHINESE COMMUNIST PARTY, 2021) and the German High-Tech Strategy 2025 (GERMANY, 2019).

In all cases, it should be noted that efforts have been made to accelerate the pace of digitalization and connectivity in a comprehensive way (society, government, services, industry, agriculture), whether to achieve these new priorities or compete for new spaces and niches in global value chains.

Digitalization is critical to leveraging positive externalities to the economy and society, providing more systemic gains in productivity, transforming modes of socialization, consumption patterns, and lifestyles. This vision requires special attention to the development of advanced semiconductors and not only to reverse the deceleration of Moore's law but also for geopolitical reasons, as demonstrated by the sharpening of technological rivalry between the US and China in this and other fields.

From the point of view of government policies, investments in new infrastructure must be associated with high-power digital platforms and systems, such as IoT, industry 4.0, 5G telecommunications, and artificial intelligence systems. Such investments require greater public support for R&D, education, and enabling training *vis-a-vis* digital technologies, "mission-oriented" mobilizing programs, and greater promotion of national S&T ecosystems.

Induced by policies and driven by competition, digitalization is pervasively projected at the meso plane. Its most advanced systems (4.0, 5G, and AI) accelerate the emergence of new, more competitive business models that, in their most generic form, result in integrated (I), connected (C), intelligent (I), and serviced (S) companies. ICIS companies impose changes in the competition patterns because, following one of the Schumpeterian hypotheses, they will have a greater capacity to grow ahead of their competitors resulting in transformations in the market structures where they operate.

Horizontal, comprehensive, and online digital integration into value chains is intensifying in most developed economies. As a result, the various links in value chains and intra-company activities will become closely integrated (regardless of their respective physical locations). Given this, one can assume that national "borders" will lose importance in the context of the division of labor within transnational companies.

They will be smart chains because economic and technical data will be captured, stored, and processed online, so that through artificial intelligence algorithms, decisions on actions and reactions to production and marketing phenomena can be delegated to equipment and digital systems, enabling automatic optimization and remote management of the entire chain[9]. For example, with the spread of 5G the precision of efficiency parameters will increase in all links, combining scale with differentiation and customization of connected/intelligent products

[9] The dissemination of such integrated-intelligent models is intensive in big data processing, demanding more efficient and more accessible processors (universal and/or specialized) in terms of cost-benefit. Given that, monitoring the technical progress of semiconductors is paramount, in response to new national development initiatives.

and, at the limit, personalizing such consumer goods. For example, precision agriculture and personalized medicine are already operational concepts based on clusters of combined innovations. Models of this nature allow companies to provide intrinsically complementary goods and services and, instead of just selling, to market the use of goods in the form of services or associate them with new AI-based services.

In short, the increased digitalization of value chains combined with AI provides different opportunities, such as the emergence of new business models that are intensive in services, customizations and/or personalizations; the greater intertwining of global or regional value chains, enabling optimizations and additional efficiency gains; the reduction of entry barriers for more efficient, more flexible competitors with differentiated management models, making value chains and market structures more unstable.

These transformations will inevitably affect the microeconomic level. Under the competitive pressures induced by digitalization and the differentiation of business models, incumbent companies will need to transform themselves promptly,, even if they are leaders today. Greater permeability to leadership changes is indeed observed in many sectors. Therefore, the slowness in absorbing digital innovations can be costly to leaders who become laggards and their respective value chains. On the other hand, it is reasonable to expect that, aware of the importance of digitalization for sustaining leadership and favorably entering global value chains (GVCs), competitive companies will proactively implement plans for learning and adopting 4.0 systems.

In turn, companies characterized by the dominance of non-digital technologies or a punctual and compartmentalized digital presence are the least capable and tend to take greater risks. For no other reason, advanced industrial countries have been adopting active policies to encourage digitalization, especially aimed at small and medium-sized companies and sectoral chains considered strategic (ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, 2021).

Maximizing the effectiveness of development policies increased the value of research into the motivational, inducing, and conditioning factors for adopting business strategies for digitizing their functions. Microeconomic factors can and should be the object of valuable analysis to obtain more efficient public policies, including the perception and business expectations regarding digitalization; the levels of training of managers and workers; the existence or not of advance plans; correlations between propensity to adopt more updated stages of digitalization and R&D practice, training in digital technologies, exposure to trade via exports, and/or participation in GVCs, origin of capital, relationship with S&T ecosystems.

3. The importance of expectations in the formation of business investment and innovation strategies (Keynesian approach) and its complementarity with the Schumpeterian view

In his *The General Theory of Employment, Interest and Money* (1936), especially in part IV (*The inducement to invest*), Keynes focuses on the formation of expectations of business agents, essential to their decisions to invest and innovate in the context of a capitalist monetary economy where, depending on the state of confidence, the credit system and the capital market can leverage financing and funding for investment and innovation or operate as a defensive refuge to the allocation of capital in liquid and safe assets (high quality public bonds). As discussed later, Keynes's and Schumpeter's views on the innovative entrepreneurial role are remarkably compatible and complementary.

For Keynes, expectations are subjective and based on a greater or lesser degree of conviction. Despite their changeability, expectations are fundamental since they subsume business agents' perceptions of the future evolution of macroeconomic conditions, such as market and job growth, the prospects for interest rates, exchange rates and inflation, credit conditions, finance, and public debt. They also related to their perceptions of the meso and microeconomic conditions faced by companies, including infrastructural externalities, specific conditions of taxation and tariff protection, barriers to entry, the competitive performance of internal and external competitors, conditions and costs of supply chains and distributors, the behavior of consumers/users and, no less relevant, the speed and impact of the technical innovations on the horizon.

Thus, given the specific conditions of each company's expected profitability, liquidity, indebtedness, technical training, and idleness, and considering how expectations are conformed (macro, meso, and micro), decision-makers evaluate scenarios, carry out risk/return calculations, and define their investment strategies (or not) in fixed and intangible capital (technological knowledge).

Therefore, the formation of expectations grounds economic calculation and the state of trust and willingness to risk investing and innovating. Expectations originate from each entrepreneur's vision and, through social interaction, and they may (or may not) lead to the establishment of dominant conventions regarding future scenarios (long-term expectations). If these conventions draw an economically promising picture, supported by a large majority of opinions, the feeling of confidence that leads to decisions to immobilize capital in new productive assets and to innovate in new products and processes is consolidated (KEYNES, 1978).

However, conventions change and can break down, whether due to the maturation and exhaustion of economic cycles or the impact of unforeseen negative shocks, such as failures of systemically essential entities (mainly banks), large supply shocks, adverse social or natural events, epidemics, and others. The violent and unforeseen rupture of established conventions dissolves the state of confidence, and it throws agents into uncertainty, making prospective calculations based on the attribution of subjective probabilities to scenarios favorable to the return on capital unfeasible[10]. Amid the uncertainty, the dominant behavior will be defensive, through the search and maintenance of business liquidity, interrupting the immobilization of capital in capacity expansion and innovation. As long as this state of preference for liquidity lasts, investments in production and R&D tend to remain retracted.

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[10] On the formation and rupture of conventions, see Orléan (2004) and Cardim de Carvalho (2014).

Between the two extreme states – high confidence or thick uncertainty – it is common in market economies to form more volatile and non-extreme conventions, resulting from shallow confidence, in which optimistic opinions and sentiments predominate (*bull markets*) and others pessimistic sentiments predominate (*bear markets*). In this type of macro-scenario, the alternation of conventions can generate ambiguous and volatile states: moderate and fragile optimism or moderate instability resulting from precaution and caution.

Moderately unstable macro scenarios tend to result diverse expectations, with more tenuous and changing polarizations. Under these circumstances, at the microeconomic level, the opinion or individual conviction of decision-makers about the future tends to predominate (long-term expectation) in the light of financial conditions and the specific peculiarities of their respective markets, such as tax, regulatory constraints, competitive pressures, level of idleness, and evaluation of the expected risk-return of investments in technological innovation.

One must highlight that under moderately unstable macro scenarios, business expectations can be strongly influenced by the mesoeconomic scenario, especially in the case of sectors/markets where the dissemination of innovative products is exuberant in a Schumpeterian sense. For example, in the 1990s, although the macro scenario in developed countries was moderately unstable, the ICT complex nevertheless supported continuous high rates of expansion in demand and investments in fixed capital and innovations (CASTELLS, 1999; WORLD BANK, 2005). This example illustrates how the Schumpeterian view - which highlights the autonomous dynamism of the expansion and dissemination of critical innovations - can converge with the Keynesian view - which sees the possibility of forming robust conventions based on optimistic risk-return perceptions at the micro and meso-economic levels[11].

[11] In the 1990s, a significant advance in the structuring of the internet took place, with the emergence of wifi and broadband, the development of telecommunications networks and mobile devices, and the continuous progress in the capacity of processors and memories ("Moore's law"), sustaining the pace of growth of ICTs (see CASTELLS, 1999). For world economic growth in the 1990s, see World Bank (2005).

It is relevant to assess whether digitalization and environmental decarbonization programs induced by new regulations and incentives will constitute economic engines capable of sustaining world growth in a markedly unstable post-COVID-19 macro scenario. Digitalization is accelerating, driven by the diffusion of key technologies (5G, 4.0, and IoT, all combined with AI) and government programs to promote the electronic industrial complex in advanced economies, aiming to expand spaces in global/regional value chains. The other driver, also known as the "Green New Deal", has gained strength from recent decisions by governments in advanced economies to invest heavily in large decarbonization (zero net emissions of greenhouse gases) over the next four decades (INTERNATIONAL ENERGY AGENCY, 2021). These investment programs are macroeconomically and technologically relevant as they demand important innovations (for example, new sources of clean energy, such as green hydrogen, and carbon capture, use, and storage - CCUS technologies) and significant increases in efficiency in energy use resulting in a sustained drop in the energy/GDP ratio (INTERNATIONAL ENERGY AGENCY, 2021).

These two intertwined drivers combine Schumpeterian and Keynesian dimensions with the potential to unite and convince expansionist expectations for investment in R&D and fixed capital. Public investment policies (of a Keynesian nature) reinforce accelerated digitalization (of a Schumpeterian nature). On the other hand, decarbonization stems from typically Keynesian political decisions (autonomous investments induced or implemented by the State, which run ahead of demand and require innovations that will need to be fostered) and combines like a glove with the acceleration of digitalization insofar as this saves energy, materials, and other costs. It is worth underlining that the theoretical constructions of Keynes and Schumpeter are perfectly compatible and complementary (DOSI; FAGIOLO; ROVENTINI, 2010).

Keynes observes the succession of conjunctures with the expectational perspective of short and long terms, considering mainly capital management decisions. These decisions must be addressed even when the prospective calculation of economic return is made unfeasible by uncertainty, that is, the impossibility of forming subjective but reliable expectations[12] about future returns. In those circumstances, capital management focuses on self-preservation, anchored on liquidity security. And, if the spontaneous market forces and the animal spirits of capitalists do not envision attractive returns on business activity and the system falls into indefinite prostration, Keynes (1978) prescribes public investment as a way out to mobilize effective demand and resume the economic dynamism necessary for the full employment and well-being of societies.

Having highlighted the role of credit, the capital market, and financial innovations as generators of endogenous cycles in capitalist economies, Schumpeter focused his attention on technological innovation as the driving force of long-lasting cycles and sought to delineate the defining characteristics and requirements of power, autonomy, and longevity of this driving force. Although his optimistic vision is based on the hegemony of an innovative productive business community and the constant competition for profit, without which capitalism tends to lose dynamism, he does not exclude the role of the State as an inducer of innovation and the recovery of economies after strong cyclical crises, especially when they compromise the credit system (SCHUMPETER, 1939).

The views of Keynes and Schumpeter clearly converge on the crucial role of the innovative and bold business community in the face of risks. Keynes criticizes the predominance of speculation over the business impulse driven by *animal spirits* in the same way that Schumpeter values and distinguishes *entrepreneurship* from capitalism.

Consistent with the Keynesian view, expectations are volatile and relevant to the moment in which they are formed, insofar as they portray the perspective of business agents in specific situations,

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[12] Keynes makes it clear that one cannot speak of "probable expectations" ("or improbable") in the sense of mathematically calculable statistical probabilities, since the market system works under uncertainty. However, one can talk about the conviction or trust deposited in the expectation, a trust that depends on the verisimilitude and reliability that the agents attribute to the best projections made (KEYNES, 1921).

whether more optimistic or more pessimistic, in the macro, meso, and microeconomic levels.

The fundamental hypothesis is that investment decisions concerning R&D and innovation (including, in the case of industrial firms, decisions related to the adoption of more advanced digital technologies) are positively correlated with the state of confidence of agents about expectations of market growth and conditions of economic return that can pay them back satisfactorily.

However, in situations of weak confidence at the macro level, the propensity to invest in innovation will depend more on animal spirits or the degree of entrepreneurial boldness in relation to their own business. It means that, except in extreme situations of panic and collapse of confidence, meso and microeconomic expectations can prevail over lukewarm or less encouraging expectations at the macro level. This possibility is perfectly intelligible from a Schumpeterian point of view, in the case of sectors or companies whose innovative activity provides them with new markets and/or cost and profitability advantages, even in periods of low growth or macroeconomic stagnation. In this sense, in highly innovative sectors, bold microeconomic strategies of indebtedness and corporate risk-taking can prevail to accelerate investments as long as banks and the capital market match them. In industries negatively affected by innovation – by Schumpeterian "*creative destruction*" – microeconomic expectations and strategies could or should be defensive and averse to leverage risks, in order to avoid bankruptcies. However, a coherent concatenation of expectations at the macro, meso, and micro levels is never guaranteed. Expectation dissonance can occur and cause increasing instability – instability that is endogenous to the modern capitalist system under the aegis of a relevant financial system and protagonist of financial innovations, as well dissected by Hyman Minsky (1975), a prominent interpreter of Keynes[13].

[13] See Minsky (1975), especially chapters 4, 5 and 6 where he describes how the changeability of expectations endogenously affects interest and calculation rates and, consequently, the valuation of instrumental asset prices and wealth securities

The combination of Keynes and Schumpeter's complex and holistic visions is undoubtedly analytically enriching for the challenge of understanding the digitalization of industrial companies and their strategies and conditions for adopting digital technologies from the perspective of revealed business perceptions and expectations, especially in developing countries. Given their role in shaping the expectations of economic agents, the macro and mesoeconomic conjunctures need to be contextualized appropriately, especially when analyzing and comparing the stages of digitalization and adoption plans for more advanced generations.

Indeed, how innovation decisions (including digitalization) interact with microeconomic expectations about the respective rates of return is influenced by how the creation of bank credit and the capital market movements instigated cyclical instability. Minsky recalls that Keynes underlined the propensity of small and medium-sized agents to imitate the behavior of prominent capitalists, assuming that the latter have informational superiority. Such a propensity leads to behavior feedback and favors both expansionist cycles and recessionary movements.

Thus, the Keynesian and Schumpeterian theoretical frameworks can provide bases for interpreting the business expectations captured in the two surveys to Brazilian industrial firms conducted in the 2017-2018 and 2020-2021 periods. The hypothesis to be tested is that in a conjuncture of firm confidence in the expansion of markets, effective plans for adopting digital innovations by leading companies would induce profuse imitative movements. Conversely, adoption would have limited propagation in a situation of low confidence. Observing these behaviors can reveal understandings regarding the degree of awareness and business mobilization towards the advanced digital manufacturing standard and the possible correlations between awareness, mobilization, and variables such as R&D, training, exports, origin of capital, and interactions with innovation ecosystems, among others.

4. The structuralist view (Celso Furtado) on how technical progress tends to produce structural heterogeneity and the institutionalist contribution of Abramovitz

The genetic heterogeneity inherent to the social formation and peripheral production systems and the unequal dynamics of core-periphery relations poses a significant challenge to the catching-up possibilities of developing economies. Therefore, one must pay attention to the risks of deepening the 'digital divide' arising simultaneously from the accelerated digitalization of advanced economies and the delay and hardship of digitalization in developing economies. Celso Furtado's structuralist views (representing ECLAC thought) and Moses Abramovitz's institutionalist views will help clarify the constraints and State policies needed to face this contemporary challenge.

Structuralism explained how the colonial-slave expansion of mercantile capital between the 16th and 18th centuries shaped the historical formation of peripheral societies. After the 18th century, the advance of industrial capitalism transformed the international trade system under a new international division of labor, characterized by ECLAC as a "center-periphery system".

Under the direct inspiration of Raul Prebish, Celso Furtado dissected the asymmetric and dependent dynamics of the center-periphery relationship. Central economies concentrate the technical dynamism and the hegemony of the interests of large industrial and financial capital. On the periphery, the exports of raw materials was an integral part of and dependent upon the dynamism of the center's production forces. However, the capitalist export sector, which introduced wage-earning work, coexisted with concentrated agrarian structures, with a non-salaried population subsisting under archaic forms of domination. Manufacturing development in the periphery was incipient, lacking in capital and technologically outdated.

Technical progress played a vital role in the center-periphery dynamics. Within the scope of the central industrial economies, technical progress generated systematic gains in productivity that were then converted into more profits and wages. In contrast, productivity gains obtained from the exports of peripheral economies were not fully appropriated, for two reasons: 1) the terms of trade tended to deteriorate, attenuating the exporters' flow of profits, and 2) because in most peripheral economies, the elastic supply of labor emanating from stagnant regions would limit the conversion of productivity gains into real wage increases.

Thus, the periphery's social, economic, and technical heterogeneity tended to reproduce itself. In addition to enjoying their own productivity gains, central economies could nevertheless absorb part of the potential gains from peripheral economies through lower raw material prices. This deterioration in terms of trade to the detriment of the periphery constituted a long-term trend arising from the differences between the income elasticities of demand, which are higher for manufactured goods, and the income elasticities of demand for raw materials and food products, which are generally lower than one.

In the face of these conditions, the peripheral economies chronically lived with a shortage of hard currency. Except during cycles of prices favorable to commodities – which were not very long-lasting – accelerations of industrial growth in the periphery resulted in elastic increases in imports of capital goods and basic inputs, fueling trade deficits that strangled the capacity to import, reduced investment, depreciated the exchange rate and caused inflation.

These relatively frequent crises caused fixed capital formation to discontinue, reiterating machines and equipment's age and technological heterogeneity. In the periphery, industrialization faced structural difficulties, exchange rate instability, and punitive inflationary tensions for urban wage earners and industries dependent on imported inputs.

The economies of scale increased with the emergence of Schumpeter's 3rd Kondratieff at the end of the 19th century and its rapid propagation in the 20th century – with the spread of internal combustion engines, electrical machines, the chemical industry, steelworks, oil extraction, and refining. As capital needs grew, industrialization became even more difficult for the periphery.

Reflecting on these difficulties, in the light of social, institutional, and social backwardness conditions, Moses Abramovitz sought to understand the problematic saga of late industrialization countries in Asia and Latin America, which, throughout the 20th century, would reveal few success cases until the beginning of the 1980s.

If, on the one hand, the increase in production scales and capital magnified challenges to peripheral industrialization, on the other hand, the possibilities of *catching up* based on the advantage of skipping stages by importing technology embedded in state-of-the-art capital goods facilitated advances (ABRAMOVITZ, 1986), reinforced by industrial policies and the formation of large national business groups (Asia) or through the entry of multinational subsidiaries (Latin America) – peculiarities that deserve attention.

Abramovitz argued that accelerated catching up could enable the formation of newer, more homogeneous, and efficient industrial structures, as occurred after World War II in Japan, Western Europe, and a few late industrializing economies, providing them with higher productivity growth rates, so as to converge or even surpass the levels of the most advanced economies at the time. According to the author,

> [...] [t]hose who are behind, however, have the potential to make a larger leap. New capital can embody the frontier of knowledge, but the capital it replaces was technologically superannuated. So – the larger the …gap… between leader and follower, the stronger the follower's potential for growth in productivity. (ABRAMOVITZ, 1986, p. 386).

An institutionalist historian attentive to facts and statistics, Abramovitz was quick to critically qualify this simple hypothesis of "catching up". The catch-up potential was neither automatic nor uniform across countries and would depend on the social capability accumulated in the respective societies, that is, on the qualitative advancement of education and political, commercial, industrial, and financial institutions[14].

In turn, faced with the technological, scale-related, and financing challenges typical of the peripheral import substitution processes, Celso Furtado reaffirmed the need for State action guided by long-term planning: "[...] the work of rebuilding structures requires guiding action that can only come from the State. The complexity of the task to be carried out requires a global, synchronic and diachronic view, which is only obtained with planning" (FURTADO,1997, p. 35). Furtado also observed that the massive internationalization of prominent American and European industrial companies in the post-war period introduced an important player into the Latin American scene. Multinationals could take advantage of tariff protections established by the import substitution policy to accelerate catching-up, directly taking over the most dynamic markets.

On the other hand, as those companies took over the markets, it interrupted, "in general, the formation of a class of entrepreneurs with a clear national feeling. [...] National business action was restricted to secondary or decadent sectors" (FURTADO, 1997, p. 73). This relevant presence of transnationals resulted in a relative loss of national sovereignty insofar as the respective decision centers remained in the headquarters abroad. Furthermore, the loss of relative position of the national business community, *vis-a-vis* the preponderance of subsidiaries of transnationals, would reinforce cultural and technological dependence and reduce the propensity to innovate on the part of national companies.

Under the 2nd Industrial Revolution (3rd Kondratieff), the absorption of technologies by latecomers resulted primarily from new equipment with scale economies. Sustained accumulation of fixed capital over several years accelerated *catching up* and reduced the heterogeneity of the capital stock, incorporating relevant productivity

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14 The technological dimension of social empowerment was also valued by Abramovitz (1986, p. 402-405) as a relevant condition for catching up or, alternatively, for the rejuvenation of advanced economies.

gains. Productivity gains via the absorption of embodied technologies could be obtained in many sectors by the merely importing and using state-of-the-art machinery and equipment, with no endogenous R&D efforts required. This circumstance clouded the importance of the intangible factors of social empowerment, making endogenous R&D activities rarefied. Thus, independent innovation in processes and products would only advance with government policies to encourage ST&I in the country, which, objectively, was limited to a few sectors.

However, the premise of easy absorption of incorporated technologies could not be assumed in the face of the 3rd Industrial Revolution, characterized by the rapid development of ICTs in the 1970s, 80s, and 90s. At this stage, the disembodied components of technical progress gained importance due to the need to accumulate specific knowledge of programming and customization of software tools, to acquire training as a user of computerized equipment, and to obtain a minimum of mastery over services intensive in knowledge to be able to capture the then emerging competitive advantages.

The emergence of the 4th Industrial Revolution in the first two decades of the 21st century - characterized by the integrated, connected, and intelligent digitalization of manufacturing - deepened the relevance of technical progress not incorporated in machines and equipment. As highlighted in the previous section, digitalization has increased the importance and complexity of services that are intensive in technological knowledge and the development of new services based on artificial intelligence algorithms. Furtado and Abramovitz stressed the increased role of education and social training and called attention to their remarkable cumulative nature. In recent decades, scientific, technological, and innovation training has become more complex, multidisciplinary, open, and cooperative involving many actors and forming ecosystems that accumulate synergies resulting from tacit and cumulative learning.

The increasing importance of cumulativeness in social empowerment makes it more difficult to address heterogeneity and inequality in developing countries. Heterogeneity combines diversity and inequality of skills, with inequality being a factor that hinders development by systematically concentrating wealth, income, and training opportunities, both in the social (citizens) and business (companies and entrepreneurs) spheres.

The historical view of Abramovitz and Furtado reveals that the *lato sensu* structural heterogeneity is due to the significantly unequal genetic characteristics of social formations, inherited from the past and only partially attenuated by the cycles of industrialization and urbanization under the 2nd Industrial Revolution, especially after World War II. In Latin America, the exchange rate and inflationary crises of the 1980s and 1990s led to stabilization plans with very high interest rates and an appreciated exchange rate, blocking industrial progress and a possible reduction in structural heterogeneity and social and regional inequality.

Industrial heterogeneity refers to the coexistence of technological standards from different industrial generations (1st and 2nd Industrial Revolutions or 3rd and 4th IRs), which can occur within sectors or within companies. In turn, the industry's digital heterogeneity, relevant to the stages of the 3rd and 4th IRs, concerns the coexistence of machines and equipment equipped with controllers, computers and digital platforms of different technological generations, as classified by survey I-2027 under groups G1, G2, G3 and G4[15]. These stubborn heterogeneities certainly hinder the development processes.

Abramovitz (1986, p. 387-390, p. 405-406) emphasizes that advancing social capacities to innovate depends on favorable macroeconomic and institutional factors and the faculty of the follower economies (and respective companies) to develop endogenously and cumulatively more capacity ("forge ahead") aiming at the technological frontier. Furthermore, one needs to persevere over time to form ecosystems with the accumulation of technological knowledge and a critical mass of human resources qualified in STEAM (Science, Technology, Engineering, Arts, and Mathematics) areas. Referring to the social

[15] The definition of groups from G1 to G4 can be found in the Introduction, footnote number 3.

capabilities of Europe and the United States and the potential to remain at the technological forefront in relation to emerging countries, Abramovitz (1986, p. 405) underscores the cumulative nature and likely resilience of these advantages:

> These are their high level of general and technical education, the broad bases of their science, and the well-established connections of their science, technology, and industry. These elements of social capability are slow to develop but also, it seems very likely, slow to decay.

In short, holistically, structuralism and institutionalism underline the framework of international economic relations (especially trade and capital flows, commodity prices, technology, and human resources) and highlight the role of cultural, political, and institutional factors – to be analyzed in their respective historical contexts. Both approaches emphasize the role of social empowerment at the macro, meso, and micro levels. At the macro level, it is represented by the political and institutional capacity to conduct monetary, fiscal, and aggregate investment policies that combine stability and long-term planning and by the quality of the educational system. At the meso level, it is represented by endowments of resources, trained workers, sectorial policies for import substitution and export promotion, degree of exposure to internal and international competition, tax and regulatory systems, organization and bargaining power of workers, income transfer mechanisms and mitigation of social and regional inequalities, provision of logistical and urban infrastructure, public support for ST&I, etc. At the micro level, it is represented by the training, culture, expectations, and prospective vision of entrepreneurs, which allows - following Abramovitz - to organize and differentiate companies into three analytical categories, namely: leaders (or forgers of the future), followers (who seek to catch up) and outdated (whose training is low and vision of the future, limited).

From the perspective of research that examines the expectations, capabilities, and digitalization plans of industrial companies in developing countries (see UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, 2019; RODRIK, 2018), it is necessary to examine the historical context and the determinants derived from the international division of labor in world industry, with an emphasis on the evolution of global value chains in the last two decades, which concentrated in Asia and especially in China the supply of industrial inputs, parts, and components and provided accelerated catching up.

It is particularly interesting to focus on the debate about possible rearrangements of industrial GVCs, assessing the opportunities accessible to Latin America and Brazil vis-a-vis the political competition between the two leading industrial powers of today, China and the USA, and considering the requirements derived from digitalization. Such an examination should consider the role of transnational corporations' subsidiaries and the possibility of encouraging them to adopt advanced digitalization, including the respective value chains, as well as the correlations between digitalization processes at the micro level with specific mesoeconomic determinants, such as exposure to international trade via exports, the practice of R&D, the provision of training activities, the existence of interactions with ST&I institutions (notably, in innovation ecosystems) and benign 'contagion' with other companies in the same region/sector. In addition, it should assess the capabilities and factors internal to companies that affect the adoption of more advanced digital generations, such as awareness and prospective positioning of business leaders and readiness for the future assessed by the existence (or not) of strategies/plans and effective digitalization projects.

5. Notes to the Research Agenda in developing economies

In this section, we point out how the reference map suggested in the previous sections can be useful for analyzing the challenges of catching up and, especially, industrial digitalization in developing countries.

From the standpoint of business strategies for adopting digital technologies, it is vital to take into account: i) the maturity of the current stage of the long technological cycle (4th Industrial Revolution); ii) the macroeconomic regime of wealth inflation derived from very low or negative interest rates after the great global financial crisis of 2008-09; iii) the dilemmas arising from the management of monetary policies after the Covid-19 pandemic in 2020-2021 and the solid global inflationary surge resulting from supply imbalances (exacerbated by the Russia-Ukraine war in 2022-2023). Considering these issues is paramount to developing countries since they strongly impact their economic calculation conditions, including country risk, interest, and exchange rates.

In this complicated scenario, it is relevant to assess whether or not the autonomous force of the digital revolution – whose endogenous dynamic factor, Moore's Law, already shows signs of slowing down – could maintain the impetus of technical progress in the face of the renewed financial instability resulting from recent increases in world interest rates. In this sense, Keynesian and Schumpeterian theories help examine how potent and effective the large-scale economic stimulus programs recently launched in the US, the EU, China, and other economies are. Furthermore, it is worth asking how a kaleidoscope of business expectations, at the meso and microeconomic levels, would tend to become more unstable in a global scenario of technological race under great geopolitical tension.

Hence, it is advisable to be cautious about the sustainability of the exponential performance of the global giants of digital technologies in the face of the following difficulties: a) the possible slowdown in the rapid integration of low-income classes and small entrepreneurs to the Internet in view of the weakening of the tendency to drop in prices of digital technologies; b) the challenge of implementing, offering, and accessing 5G networks at affordable prices; c) the challenge of sustaining the offer of more powerful smartphones at decreasing prices.

These challenges escalate for developing economies, marked by structural and social heterogeneities. The structuralist and institutionalist theoretical frameworks derived from Furtado's and Abramovic's thinking can offer inspiration and research hypotheses. In this sense, one could inquire about the specific conditions of social empowerment in developing economies in their macro, meso, and microeconomic dimensions. These conditions are marked by significant structural, industrial, and digital heterogeneity, translating into inequality in the capabilities of companies, citizens, and institutions.

Admitting that catching up depends on the formation and accumulation of social skills a la Abramovitz, it is intuitive that its reach requires persistent processes of reducing social heterogeneity/inequality (educational, salary, income and wealth) and productivity (industrial, agriculture, extractives and services). The perpetuity of these processes depends on a macroeconomic policy that supports high investment rates, as well as efficient, stable and long-lasting public policies on education, health, ST&I and digitalization. The basic hypothesis is that the inability to sustain firm macroeconomic performance supported by robust cycles of capital formation, problematizes the cumulative construction of national capabilities.

Indeed, frequent crises, typical of peripheral countries, paralyze investments at various levels, including micro and mesoeconomic investments in training, and tend to reverse previous advances. If catching up processes were already challenging under the technical progress incorporated in machines, it has become more difficult in recent decades as it depends much more on social training. Therefore, peripheral countries, whose education and ST&I systems are less developed and more vulnerable to fiscal stress, run more frequent and palpable risks of delay in the sphere of industrial and business innovation.

An example of this is the disappointing social and economic performance of Latin America and the Caribbean (including Brazil) in the 2014-2023 decade, according to a recent ECLAC report[16] that

[16] See "*Halfway to 2030 in Latin America and the Caribbean*", Forum of the Countries of Latin America and the Caribbean on SUSTAINABLE DEVELOPMENT, Santiago, 25-28 de Abril, 2023, Chapter 1 (ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN, 2023).

sees a structural crisis of the "development model of the region". This development crisis is reflected in the fact that the 2014-2023 decade shows a much lower performance than that observed in the "lost decade" of the external debt crisis between 1980 and 1990[17]. Furthermore, due to the emergence of strong inflationary pressures in the period of post-pandemic economic recovery - pressures exacerbated in 2022 by the Russia-Ukraine War - there was a sharp rise in interest rates with a significant deterioration in expectations and skepticism regarding the growth potential in the coming years.

However, despite the adversities, it is reasonable to expect that the group of exporting industrial companies - aware of the relevance of digitalization for competitiveness and active insertion in GVCs - will prepare plans for the adoption of 4.0 systems. For example, subsidiaries of transnationals based in developing countries (including Brazil) can implement shared adoption processes with the parent company or with more advanced counterparts. Likewise, market leading national companies, exporters and practitioners of R&D, will tend to adopt plans for digitalization 3.0 and 4.0 despite the prevailing uncertainties in the respective domestic markets. These hypotheses seem plausible *a priori* and could be tested based on field research according to the empirical articles presented in this publication.

On the other hand, it seems implausible to assume that companies lacking skills and resources, mainly MSEs, can adopt proactive digitalization strategies without the support of technical assistance policies and accessible financing, especially under adverse macroeconomic conditions. If this hypothesis is true, the risk of exclusion and deepening of digital heterogeneity falls on the large contingent of outdated companies (concentrated in generations G1 and G2) which, in 2017, in the case of Brazil, represented the majority of industrial companies (INSTITUTO EUVALDO LODI, 2018). It should be noted

[17] Average GDP growth in Latin America and the Caribbean between 2014-2023 (2023 being the estimated projection for this year) is expected to reach just 0.8% per year, in contrast to the 2.0% per year observed between 1980 and 1990, according to the report "*Halfway to 2030 in Latin America and the Caribbean*" (ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN, 2023).

that about a third of this contingent did not even consider adopting digitalization plans in the future.

Effectively, in the Brazilian case, in a scenario of low growth and in the absence of digitalization policies, it is plausible the hypothesis that the business system would tend to polarize between a minority group of qualified companies, which will match the 4.0 standard, and a numerous group of lagging companies that would not be able to advance, running the risk of exclusion. On the other hand, the launch of a national program to encourage lean and sustainable manufacturing combined with incentives for digitalization could prevent such polarization, since a significant portion of lagging companies is aware of this risk and aims to progress, as suggested by recent research (INSTITUTO EUVALDO LODI, 2018).

In short, the digitalization of industry in Developing Economies adds an additional challenge to contemporary catching up processes – overcoming this challenge is essential to obtaining persistent productivity gains and, consequently, to achieving a winning insertion in global chains. Therefore, the challenge of digitalization should receive high priority when designing new industrial policies[18].

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[18] Examining the challenge of digitalization in the context of contemporary industrial policies seems worthy and necessary. However, due to its complexity, it cannot be addressed within the scope of this limited article, which focused on building bridges between three major interpretative visions of industrial-capitalist dynamism (Schumpeterian, Keynesian, structuralist-institutionalist). It should be noted, however, that the present article is compatible with the new formulations of industrial policy originated in recent years by followers of these schools of thought, notably by Antonio Andreoni, Dani Rodrik, Giovanni Dosi, Ha Joon Chang, Mariana Mazzucato, Mario Cimoli, Rainer Kattel, Wilson Peres and others.

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