Emerging Technologies, Global Scenarios and Impact Analysis for Brazil

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Abstract: This paper presents the main global trends compiled from studies by leading think thanks and analyzes their impacts on companies located in Brazil. Studies on the subject produced by Gartner (2019), MIT (2019), Deloitte (2017), OECD (2011), as well as by Brazilian organizations such as CNI (2018), IEL (2017) and NEIT Unicamp (2018) were analyzed. From the discussions of these trends, an overview of the trajectory and dynamics of technological innovations in Brazil is presented.

Keywords: Emerging technologies; global analysis; Brazil trends.

INTRODUCTION

Contemporary organizational practices consist of the exploration and deployment of new technologies integrally in business, focusing on the convergence of disruptive technologies to generate more value to companies. Thus, the global industry is in a fast process of technological change and reconfiguration of its business models. Just as industry, agriculture and services are undergoing a strong transformation, as societies are changing and being influenced by major global trends.

In the future, revolutionary innovations will change the lives of people on all continents and boost the global economy. Therefore, the development of new technologies has the potential to address the key challenges facing humanity, for example by providing water, food and health care for an ever larger and older population, using resources more efficiently.

JA Goldstone in The New Population Bomb: The Four Megatrends That Will Change the World shows the importance of addressing the challenges posed by demographic change and its consequences with innovations and technology (GOLDSTONE, 2010; DE NEGRI et al, 2011).

According to the United Nation Conference on Trade and Development (2018), the cumulative nature of technological change, the convergence of technologies that have resulted in numerous combinations, the significant cost savings of systemic technologies in the markets, and the internet facilitate the generation of frontier technologies (or emerging technologies), where the development process is knowledge intensive, with the ability to generate future technology developments and to be adopted by various economic sectors in the future.

Complementarily, it is possible to verify that emerging technologies are part of revolutionary technological structures defined by Carlota Perez (2010) of technology and production processes.

According to Perez (2010), within a techno-economic paradigm, there are decreasing costs for investment and production in emerging technologies and development of organizational principles that increase business efficiency and profits. In all cases, the emergence of the paradigm depends on the pace of adoption (and consequent diffusion) of revolutionary products, technologies, and related infrastructures in the economy.

When we look at the picture of Brazil's technological and innovative complexity, we see the reflection of the trajectory of creation of scientific, technological and innovative actors, including companies, universities and the government. In this context, it is stated that Brazil has an immature technology and innovation system, something directly related to the history of its development (VILHA E MASKIO, 2016).

The country was heavily oriented until the 1980s to acquire machinery, equipment and technology from abroad, with little capacity for generating internal knowledge. Other aspects such as the disarticulation of the different institutions, which did not adapt to changes in the social, economic and technological scenario explain this pattern (VILHA, FUCK AND BONACELLI, 2013).

According to Suzigan and Albuquerque (2008), Brazilian companies formulate few demands for the scientific system, because they still use imported technology and insert little global markets (VELHO et al, 2004).

Government actions to stimulate interaction between universities and companies along Brazil's path were not enough to generate strong links. The companies did not invest in the creation of their own R&D structure and the scientific system acted as substitutes for business R&D activities, not as research partners.

Despite this scenario, the incentive framework for science, technology and innovation has grown since the 2000s.
Despite the instruments and strategies for scientific and technological development adopted in the last 15 years, there has been a slight improvement in the share of private investments in this amount, intensifying the participation of public investments (VILHA E MASKIO, 2016). Moreover, Brazilian industry has major differences in its productive and technological structures, such as scale, R&D investments and cooperation (DE NEGRI et al, 2011).

In labor-intensive and resource-intensive industrial sectors such as leather and footwear, wood and furniture, textiles and apparel, and the agroindustrial complex, mature technologies and technological change come about through the purchase of machinery and equipment. In scale-intensive sectors such as mining, basic metallurgy, electrical materials, the automobile complex, and capital goods, technological opportunities are greater than in labor-intensive and natural resource-intensive sectors. In the chemical sector, health complex, industrial production of the information technology sector is more technology intensive (DE NEGRI et al, 2011).

GLOBAL TRENDS AND TECHNOLOGY IMPACTS

From the analysis of reports and studies produced by international organizations such as Gartner (2019), MIT (2019), Deloitte (2018), OECD (2011), it can be concluded that some global trends are consensus.

In the coming decades, the megatrends that will have a strong impact on companies around the world are:

I. Demographics, which are changing and moving towards population growth and aging, as well as increasing migration and accelerated urbanization.

II. Implications of population growth for health, for example endemic diseases and challenges not yet covered by life sciences research.

III. Limited natural and energy resources as a consequence of accelerated urbanization and inclusion of populations in the modern economy. In this scenario, resource constraints are a strong trend, and world population growth is likely to lead to constraints in three main areas: energy, water, food and rarer commodities.

IV. Climate change and the growing risks to the planet’s ecosystem are megatrends related to global warming and carbon offsetting strategies. These processes enhance the importance of sustainability in all its aspects.

V. Stimulating technology and innovation to address the key challenges facing humanity is another megatrend. One of the most promising fields of innovation is digital transformation, including cloud computing, the Internet of Things (IoT), industry 4.0 /industrial Internet and artificial intelligence (AI), technology solutions that extend autonomy. Progress in Artificial Intelligence will result in breakthroughs such as autonomous cars, robots and other applications that will have a far-reaching impact.

Gartner’s famous “Strategic Technology Trend Report in 2019” highlighted significant technological advances in solutions for autonomous things, analytics, artificial intelligence, and quantum computing and blockchain (Gartner, 2019). In the annual report produced by UNCTAD (2018) current technological advances are from the fields of big data analysis, internet of things to the economic sectors of personal care, agriculture, energy and water treatment.

The study entitled “100 Radical Innovation Breakthroughs for the future” published by the European Union in Warnke et al (2019) shows technological advances in terms of current maturity, long-term diffusion potential. The report reveals a high probability of speech recognition and nanLEDs solutions, as well as automation and robotics, precision farming, gene editing and biodegradable sensors. This assessment may indicate that these technologies may develop very rapidly and together form a wave of emerging technologies over the next two decades and possibly also new techno-economic paradigms with significant use by 2038.

From the megatrends listed, the question arises of how to predict the evolution of technologies and business. Mann (2003) proposes the use of systematic analysis involving patents, academic journals and business texts. Following is a discussion on the scenario of new technologies and the reflexes for patents and innovation in Brazil.

SCENARIO OF NEW TECHNOLOGIES: REFLEXES FOR PATENTS AND INNOVATION IN BRAZIL

In advanced countries it is possible to observe an evolution of investments in R&D, implying a significant volume of disruptive technological innovations for products, services, processes, the repositioning of existing industrial sectors and the generation of new sectors (NEIT-IE-UNICAMP, 2018). In this context, developing and / or internalizing in companies some of these technological innovations is a sine qua non condition to increase companies' competitiveness.

The international studies discussed in this paper draw attention to the presence of emerging technologies associated with the IoT, nanotechnology, new materials, biotechnology and industry 4.0 in the next decade (Table 1).

In particular, the internalization of digital technologies and their broad application to industry can impact the entire business value chain, from product development, business model and partnership standards to business integration (CNI, 2018). On this trend, advances in blockchain, automation, and the Internet of Things (IoT) technologies are redefining the design of mission-critical business functions.

Another front of technological change is the development of renewable energy sources resulting from the combination of compliance with regulatory restrictions, sometimes by the possibility of seeing new business (CNI, 2018).

In the context of emerging technologies with effects on the long-term horizon, international studies highlight artificial intelligence and cognitive technologies to increase work performance in the company, by combining human and machine interaction.

Technologies whose economic impact will be more visible in the medium term to developing countries (including Brazil) include renewable energy, cloud computing, mobile
internet, internet of things, advanced oil and gas exploration, next genomic generation, autonomous vehicle, advanced robotics, automation, advanced materials and 3D printing (NEIT-IE-UNICAMP, 2018) (Table 1).

Following a similar line of analysis, a study called the ‘Technology Routes Dossier’ produced by the UFABC Innovation Agency (2016) that provided a qualified diagnosis of internationally patented technology solutions and in Brazil from 2010 to 2016 shows that most solutions with applications for Internationally performed patenting is related to the field of physics in calculation, calculation and counting; as well as solutions in electrical communication and basic electrical elements. It is also worth highlighting technological solutions in fields associated with medical sciences and personal hygiene, as well as chemistry and mechanical engineering.

In Brazil the study points to a significant volume of patent applications associated with medical sciences and personal hygiene, as well as agriculture and livestock. The results also reveal a volume of patents in the area of processing and transportation operations.

| Maintechnological areas | Brazil | International Context |
|-------------------------|--------|----------------------|
| Renewable energy, cloud computing, mobile internet, internet of things, advanced oil and gas exploration, next generation genomics, autonomous vehicle, advanced robotics, automation, advanced materials, 3D printing. | Artificial intelligence, internet of things, nanotechnology, new materials, biotechnology, industry 4.0, renewable sources of energy. |

Source: DE NEGRI et al (2011); NEIT-IE-UNICAMP (2018); IEL (2017).

It is a fact that Brazil has a structural deficit in the medium and high technological intensity sectors. The generation of commercial efficiency in Brazil has been sustained in the low-tech sectors producing agricultural and mineral commodities (NEIT-IE-UNICAMP, 2018) (Table 2).

In economically advanced OECD countries, the proportion of business participation in the overall volume of patent applications is the opposite of the Brazilian case, where universities and technology institutes have the largest patenting effort in the country. This point indicates that the Brazilian productive sector - the major vector responsible for the conversion and economic impact of research into innovative products and processes for the markets, presents a timid expression of results in this direction, at least in the generation of critical knowledge capable of intellectual protection in the world.

| Period | Past (1930-2000) | Present (2000-2020) | Future (2020 ahead) |
|--------|-----------------|---------------------|---------------------|
| Technological trajectories (main areas) | Steel, petroleum, petrochemical production, iron ore, pulp and paper extraction, heavy machinery and electrical equipment, automotive, electronics, information technology, telecommunications. | Leather and shoes, wood and furniture, textiles and clothing, agroindustrial, extractive, basic metallurgy, electrical materials, automobile complex, capital goods, chemicals, health complex, cleaning and perfumery, information technology industrial production, energy. | Renewable energy, cloud computing, mobile internet, internet of things, advanced oil and gas exploration, next generation genomics, autonomous vehicle, advanced robotics, automation, advanced materials, 3D printing. |
| Key features | High degrees of production diversification; insufficient internal technological capacity. | Acquisition of technology incorporated in machinery and equipment. | Increasing returns to scale. |

Source: Vilha, Fuck e Bonacelli (2013); De Negri et al (2011); NEIT-IE-UNICAMP (2018); IEL (2017).

Table 2 provides a picture of the technological trajectories taken by Brazil in its business development. It is important to show that there are no ruptures between the temporal delimitations proposed for analysis, but delimitative simplifications for interpretations of the Brazilian case.

From a temporal perspective, the overview reveals Brazil's clear competences in sectors that focus on expanding production capacity, in industrial sectors that are far from the technological frontier.

On the other hand, Table 2 shows an opportunity that can be seized by Brazil in the reconversion and development of technologies in the context of the 'industry 4.0', which to some extent may appropriate Brazil's vocation to mobilize in trajectories with emphasis on production structures. The capital goods, agribusiness and automotive industries present efforts and potential to exploit 4.0 technologies in the competitiveness of their business.

Industry 4.0 emerges from enterprise manufacturing structures with very unique characteristics and combine the use of exponential technologies such as 3D printing, technology sensors, artificial intelligence, robotics and nanotechnology to compose intelligent machines, information storage systems, production facilities that are able to exchange information autonomously, triggering
actions and controlling each independently (INDUSTRIE 4.0 WORKING GROUP, 2013).

LIMITATIONS AND CHALLENGES OF COMPANIES IN BRAZIL TO ESTABLISH INNOVATIVE ACTIVITIES

We saw in the previous sections that the technological scenario coupled with Brazil's political and economic situation represent enormous challenges in a country whose socioeconomic development is still incomplete. The development and use of certain disruptive technologies in industrial sectors is already taking place in companies located in other countries, which compete with Brazilian companies.

Brazilian companies still have a limited expression of their R&D and innovation activities. This current scenario stems from one of an industrialization trajectory strongly based on the acquisition of machinery, equipment and technology from abroad, with insufficient domestic production of knowledge (Suzigan and Albuquerque, 2008).

In addition, other variables are presented in the Brazilian case: universities seen as substitutes for corporate R&D efforts. Moreover, Brazilian companies are still little exposed to world competition - requiring higher levels of differentiation, quality and competitiveness of their products, processes and services. Guided by a short-term strategic culture and action, Brazilian companies still suffer in a context of high tax and bureaucratic burden in the country, difficulties in accessing incentives for technological and innovative development, as well as legal uncertainties in the current regulatory framework, to discipline and support industrial and technological activities.

In the analyzes produced about current and future technologies that can strongly impact the Brazilian industry, we highlight the role of technologies under the so-called 4.0 industry, which strongly imply the intensification of business productivity, despite the impact on employment. Given this perspective, the impact that the next cycle of disruptive technology development in this direction may have on the attractiveness of the Brazilian workforce to companies is striking, as these new technologies have allowed them to “do more than ever before and with fewer people.”

Given the above, Brazil faces structural, institutional, political and learning challenges to establish the process of technological pairing with economically denser countries, with a view to positioning itself closer to the technological frontier and with more skills.

Therefore, R&D activities need to be intensified in Brazilian companies. This dimension is of fundamental importance to broaden companies' skills base to innovate. To this end, it is also necessary to expand the staff of qualified people, requiring training programs for people and companies. This dimension is directly related to the positioning of relevant innovation as a strategic decision to be made by companies, namely, in their investment plans or in their strategies for acting in the markets for competitiveness.

From the state's point of view, an agenda must be adopted that gives technological and innovative development a priority role. In late-industrializing countries such as China, South Korea, innovation development and adoption strategies are legitimate action targets for their governments and build on the strengths of their innovation system to overcome their weaknesses in addressing challenges.

Thus, there is a pressing need to establish a long-term positive public policy agenda for new technologies. Formulating a technological policy that is closer to the country's economic policy and less dependent on academic instruments and models of action also seems to be important as a methodological outline of action. Strengthening the Brazilian innovation system, emphasizing the articulation, partnership and, above all, the trust between public and private actors, aiming at the exchange and complementation of resources and competences, as well as intensifying the incentive framework for the activities of development of new technologies. other important bases for the government to move forward.

Still from the point of view of the government, it is necessary to rethink its role - not diminishing its action, but transforming it, aiming to have greater competence to structure the development of science, technology and innovation in the country (in this sense, acting as a planner, inductor, coordinator of innovation incentive policies).

Given the challenges presented, it should be noted that the urgency of a new cycle of disruptive technology generation that is taking place also opens windows of opportunity for the country, from the point of view of its breadth. This means that articulated action by public and private sector investments, strategies and engagement can open up steels for Brazil's positioning in the world economic geography, so that it can keep up with the dynamism of the current technological transformations.

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