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Industry 4.0

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Abstract: *Industry 4.0 is considered a new industrial stage in which vertical and horizontal manufacturing processes integration and product connectivity can help companies to achieve higher industrial performance. However, little is known about how industries see the potential contribution of the Industry 4.0 related technologies for industrial performance, especially in emerging countries. Based on the use of secondary data from a large-scale survey of 27 industrial sectors representing 2,225 companies of the Brazilian industry, we studied how the adoption of different Industry 4.0 technologies is associated with expected benefits for product, operations and side-effects aspects. Using regression analysis, we show that some of the Industry 4.0 technologies are seen as promising for industrial performance while some of the emerging technologies are not, which contraries the conventional wisdom. We discuss the contextual conditions of the Brazilian industry that may require a partial implementation of the Industry 4.0 concepts created in developed countries. We summarize our findings in a framework, that shows the perception of Brazilian industries of Industry 4.0 technologies and their relations with the expected benefits. Thus, this work contributes by discussing the real expectations on the future performance of the industry when implementing new technologies, providing a background to advance in the research on real benefits of the Industry 4.0.*

Keywords: Industry 4.0; digitization; advanced manufacturing; industrial performance; emerging countries.

I. INTRODUCTION

Industry 4.0 is understood as a new industrial stage in which there is an integration between manufacturing operations systems and information and communication technologies (ICT) –especially the Internet of Things (IoT) – forming the so-called Cyber-Physical Systems (CPS) (Wang et al., 2015; Jeschke et al., 2017). This new industrial stage is affecting competition rules, the structure of industry and customers' demands (Gilchrist, 2015; Bartodziej, 2017). It is changing competition rules because companies business models are being reframed by the adoption of IoT concepts and digitization of factories (Dregger et al., 2016; Lasi et al., 2014; Wang et al., 2015). From the market point of view, digital technologies allow companies to offer new digital solutions for customers, such as internet-based services embedded in products (Ayala et al., 2017; Coreynen et al., 2017). From the operational perspective, digital technologies, such as CPS, are proposed to reduce set-up times, labor and material costs and processing times, resulting in higher productivity of production processes (Brettel et al., 2014;)

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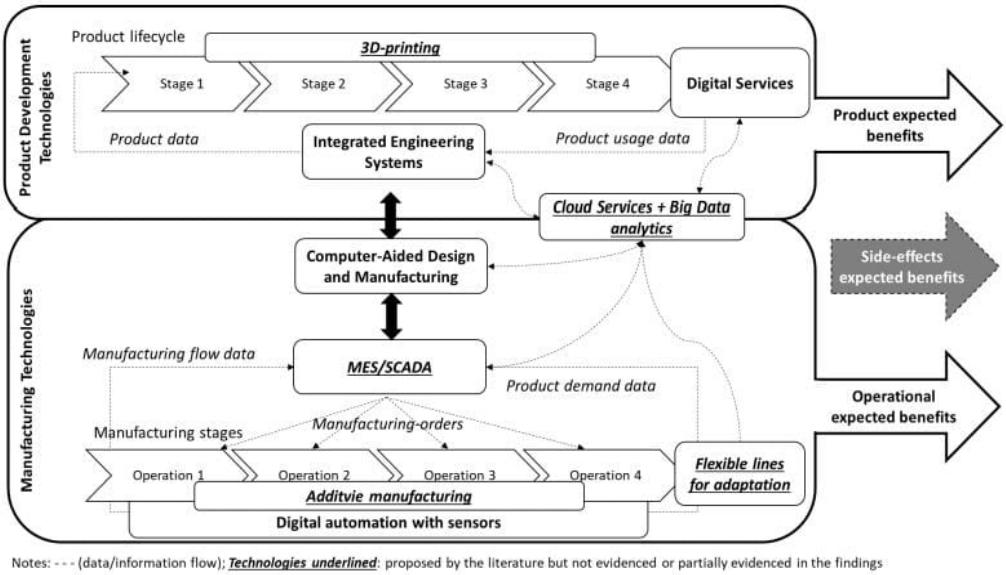

Notes: - - - (data/information flow); ***Technologies underlined***: proposed by the literature but not evidenced or partially evidenced in the findings

Figure 1 – Framework summarizing the findings and discussions of the paper

Table 1: Technologies of the Industry 4.0

Technologies	Definition
Computer-Aided Design and Manufacturing [CAD/CAM]	Development of projects and work plans for product and manufacturing based on computerized systems (Scheer, 1994).
Integrated engineering systems [ENG_SYS]	Integration of IT support systems for information exchange in product development and manufacturing (Kagermann et al., 2013; Bruun et al., 2015; Abramovici, 2007).
Digital automation with sensors [SENSORING]	Automation systems with embedded sensor technology for monitoring through data gathering (Saldivar et al., 2015).
Flexible manufacturing lines [FLEXIBLE]	Digital automation with sensor technology in manufacturing processes (e.g. radio frequency identification – RFID – in product components and raw material), to promote Reconfigurable Manufacturing Systems (RMS) and to enable the integration and rearrangement of the product with the industrial environment in a cost-efficient way (Brettel et al., 2014; Abele et al., 2007).
Manufacturing Execution Systems (MES) and Supervisory control and data acquisition (SCADA) [MES/SCADA]	Monitoring of shop floor with real time data collection using SCADA and remote control of production, transforming long-term scheduling in short term orders considering restrictions, with MES (Jeschke et al., 2017).
Simulations/analysis of virtual models [VIRTUAL]	Finite Elements, Computational Fluid Dynamics, etc. for engineering projects and commissioning model-based design of systems, where synthesized models simulates properties of the implemented model (Saldivar et al., 2015; Babiceanu and Seker, 2016).
Big data collection and analysis [BIG_DATA]	Correlation of great quantities of data for applications in predictive analytics, data mining, statistical analysis and others (Gilchrist, 2016).
Digital Product-Service Systems [DIGITAL_SERV]	Incorporation of digital services in products based on IoT platforms, embedded sensors, processors, and software enabling new capabilities (Porter and Heppelmann, 2014).
Additive manufacturing, fast prototyping or 3D impression [ADDITIVE]	Versatile manufacturing machines for flexible manufacturing systems (FMS), transforming digital 3D models into physical products (Weller et al., 2015; Garrett, 2014).
Cloud services for products [CLOUD]	Application of cloud computing in products, extending their capabilities and related services (Porter and Heppelmann, 2014).

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II. ADVANTAGES OF INDUSTRY 4.0

- Increased quality and quantity of products, due to automation.
- Reduction of expenses, time, errors, and production risks.
- Increased personnel safety.
- Instant access to digital information.
- Development of a new dimension of business competitiveness, to meet new demanding consumer needs.
- Personalized customer service.
- Efficient management and use of resources to reduce the negative impact the industry may have on the environment.

III. DISADVANTAGES OF INDUSTRY 4.0

- Large initial investment.
- The constant progress of technology requires the company to continually update, which tends to be unsustainable for most organizations.
- It will cause a significant economic gap between companies that have adapted and those that haven't to the industry 4.0 model.
- Requires specialized personnel for the analysis and monitoring of automated processes.
- Increase in unemployment in the short and medium-term, since automated machines will displace people from their jobs in factories, etc…
- Absolute dependence on technology.

IV. CONCLUSIONS

In this paper we analyzed the perception of the Brazilian Industry about the benefits of Industry 4.0 related-technologies for three industrial performance metrics: product, operational and side-effects. Our results showed that some of these technologies are positively associated to the expected industrial benefits while others are still at a very early stage of adoption and, thus, without clear expected benefits. We discussed reasons for the lack of expectation of benefits for some of the promising technologies of the Industry 4.0 in this specific emerging industry. Our main contribution to the state-of-the-art is that we show how these technologies are used and seen in an emerging economy, since most of the studies on this matter have been conducted in developed countries. In this sense, we showed how different set of technologies are associated with different expected benefits. We showed that the Brazilian industry has not yet taken advantage from some promising technologies such as product big data analysis, cloud services for manufacturing, among other technologies for the digitalization of the factory and for the analysis of the product performance. A further contribution is that we could not find any relation between the Industry 4.0 and the expected benefits for sustainability and labor claims [SIDE-EFFECTS], which represents a different pattern when comparing to developed economies. Based on prior evidences from developed countries, we argued that since side-effects tend to be at the second level of priority in the industries, after achieving operational and product performance benefits, the Brazilian industry is still not focused on this aspect, but this deserves future investigation.

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