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AN ASSAY ON THE IMPACT OF INDUSTRY 4.0 IN THE OPERATIONS AREA

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Abstract

Recent technological innovations in the means of production, product development and distribution materials are promoting big changes in the productive sector. This set of innovations is called Industry 4.0. The purpose of this article is to study the main aspects of Industry 4.0 and analyze their impact on the means of production of manufactured goods and the supply chain. Therefore, it uses bibliographic references relating to the fourth industrial revolution (SCHWAB, 2009), Industry 4.0 (KOCH, 2014) and production management (Slack, 2009). Considerations achieved in this study will form the basis for future research on the developments of new technologies in society.

Keywords: Industry 4.0; Lot unit; Supply chain

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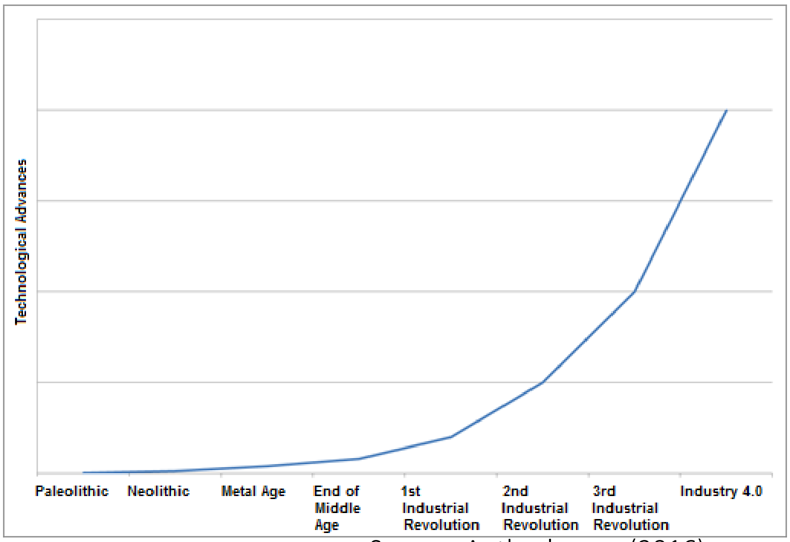
INTRODUCTION

The history points facts that mark significant changes in the social, political and economic areas. These changes are driven, in large part, by technological advances, as shown in Figure 1.

Figure 1: Technological advances over time.



Source: Author's own (2016).

The first advance occurs on the Paleolithic with the domain of fire (between 50.000bc and 40.000bc), which made possible heating at cold nights, food preparation and as a hunting and war weapon.

In the Neolithic period (around 10.000bc), there is the emergence of agriculture and animals domestication, which made humanity settle in a place, ceasing to be nomadic. The first cities appear.

In the metal age (between 5.000bc and 4.000bc), the appearance of foundry, initially with copper, a malleable metal with low melting point. Then the bronze, a copper alloy, and finally the iron, versatile and resistant material. By this point, there has been incremental advances until the end of the Middle Age (XV century) in which occurred other development outbreaks: the Gutemberg press, making possible the books availability in a bigger scale than handwritten books; caravels and compass which allowed long distance sailing, leading the new continents discoveries and the creation of new commercial routes.

In the end of the XVIII century, takes place the first Industrial revolution, in England, with the industry's mechanization, the creation of railroads and steam boats. The second Industrial Revolution occurs between the end of the XIX century and the beginning of the XX century, driven by electricity and means of communication as the radio.

The third Industrial Revolution, on the second half of the XX century, brought advances in computing, telecommunications and other electronic technologies.

What is presented today is the Fourth Industrial Revolution, or Industry 4.0, the focus of this work.

This paper has the character of an essay, based on some significant authors of the theme and a theoretical analysis on the expected impacts for the consolidation of the Industry 4.0.

2.1 Innovation

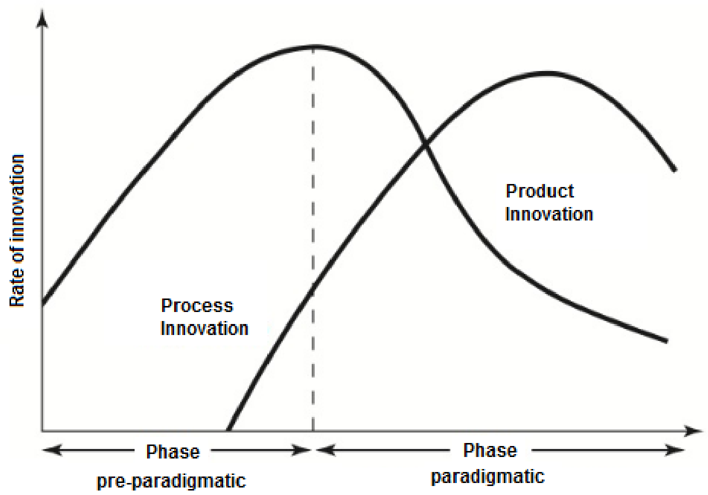
Innovation is about developing new ways to meet the established market needs, impacting goods, services and processes. The innovation is moved by the ability to establish relationships, detect opportunities and taking advantage of them, using technology and knowledge to achieve these goals.

According to the Tidd, Bessant and Pavitt classification (2005), innovation can be put into 4 categories: Product innovation, Process innovation, Position innovation and Paradigm innovation

By approaching innovation brought by the Industry 4.0, the four types of innovation are present. The product and process innovations occur in a very close manner, since the first lead to the second. The way as products are introduced (position) to the market and the companies paradigms are altered, changing the development structures, dissemination and distribution of products and services.

In Figure 2, the relationships between these innovations throughout the product lifecycle are presented. By innovating the product, the current paradigms are confronted, until after some time, it becomes the new paradigm. For this, the process is also innovated in the search to reduce costs and gains of scale, in addition to the learning process (BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2012).

Figure 2: Product lifecycle innovation



Source: Burgelman; Christensen; Wheelwright (2012).

The innovation may, still, according to it's velocity and impact, be incremental our rupture. The incremental innovation occurs in a discontinuous manner, involving the optimization or elimination of errors, without changing the product's concept, process, position and paradigms.

Rupture innovation, a concept developed by researcher Clayton Christensen, emerges as a market demand or emergence of new markets with significantly different needs and expectations, through technological breakthroughs or breakthroughs. According to this theory, the emergence of the rupture takes place as a marginal business and, like time, becomes common, usual, and changes the rules of the form of operation (BURGELMAN; CHRISTENSEN; WHEELWRIGHT, 2012).

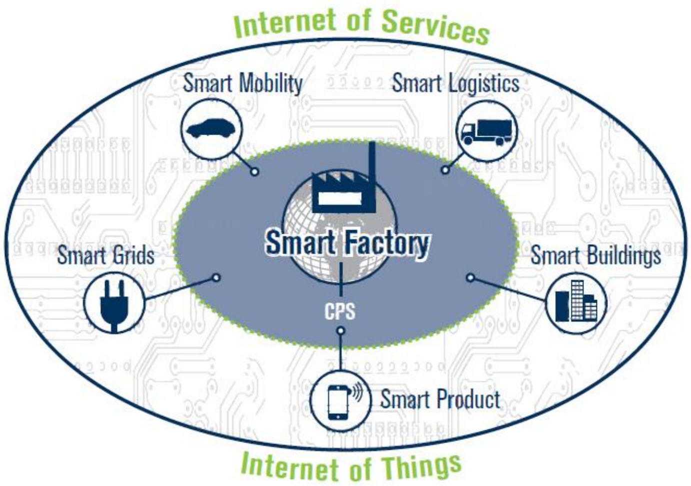
2.2 Industry 4.0

From these innovation concepts, Industry 4.0 emerges as a set of breakthrough innovations that have major impacts on the concepts of operations. The term originated in Germany during the Hannover Fair in 2011, with the aim of promoting automation and increased productivity of production lines, being adopted by European countries and spreading to the rest of the world (SCHWAB, 2016).

Industry 4.0, characterized by the increasing digitalization and interconnection of products (Santos, Santos and Junior, 2019; Silva, Kovaleski and Pagani, 2019), value chains and business models, focuses on the intelligent production of products, methods and processes (Smart Production). An important element of Industry 4.0 is the Smart Factory. The Intelligent Factory dominates complexity, is less susceptible to interference, and increases production efficiency. In the intelligent factory communicating with people, machines and resources will be as natural as in a social networking context.

The paradigm shift required for the Industry 4.0 is a long-term project and is only in a gradual process. Receiving value actions from production systems already installed plays a central role. (Forschugsunion, 2013, Koch et al, 2014).

Figure 3: Industry 4.0's connections



Source: Forschugsunion (2013).

Schwab (2016) indicates that Industry 4.0, or Fourth Industrial Revolution, goes beyond systems and connected machines.

The difference of this revolution in relation to the previous ones is the fusion and interaction of technologies of several areas of knowledge, like physics, digital and biological.

In Brazil, in December 2017, the federal government launched an initiative to insert strategic economic sectors in Industry 4.0, the Science Plan, Technology and Innovation for advanced manufacturing in Brazil, which aims to create conditions for the domestic industry to incorporate digital technologies, increasing the competitiveness of the country.

2.3 New Technologies

Focusing on the technologies closest to the area of operations (production / manufacturing, logistics), the following technologies that have emerged recently and which present a major evolution for the next years, based on Schwab's (2016) indications are:

Autonomous vehicles: vehicles that do not depend on a driver are already a reality, there are some prototypes and models already in operation. In addition to stand-alone passenger cars, which will be used to transport passengers as a taxi system, trucks also already have projects to operate autonomously. Drones are already used for deliveries, and this usage only tends to grow.

3D and 4D printing: The 3D printing process has the added advantage of adding material to the product's manufacturing, rather than withdrawing it, as in conventional machining processes (turning, milling, grinding, drilling, etc.). The materials used today in this process range from polymers to metals and concrete (civil construction). The 4D process, in development, works with materials that react to environmental conditions, such as heat, humidity or need to adapt to the space of use.

Robots: the advancement of robots will be each time faster, taking on more operational tasks, today executed by human beings. Artificial intelligence technologies will make them more flexible and adaptable to changing activities or situations that require decisions.

Nanomaterials: lighter, stronger materials (such as graphene) will change the concept of structures and manufacturing processes, replacing materials in use today, such as steel.

Restricting these innovations, because the work would be too extensive, we now analyze changes in some processes and paradigms of the area of operations.

2.4 Paradigm breaks

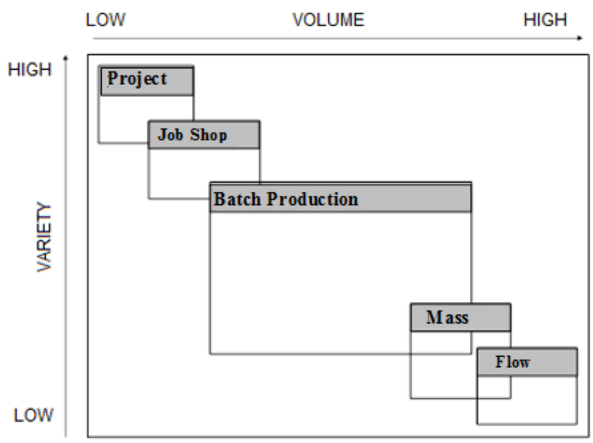
2.4.1 Single lot

Also known as Unitary Lot, it remained an unattainable goal for decades, whether in the corporate environment of the manufacturing industry or in academic discussions in the area of production and operations.

The binomial volume and output variety of traditional production systems impose a high unit cost of production for the manufacture of an item in isolation. Therefore, it is economically impractical to manufacture a unit batch.

Traditionally, production systems are represented by the Project, Jobbing, Batch, Mass and Continuous processes (Slack, Chambers, Johnston, 2009), according to Figure 4.

Figure 4: Types of Manufacturing Production Systems

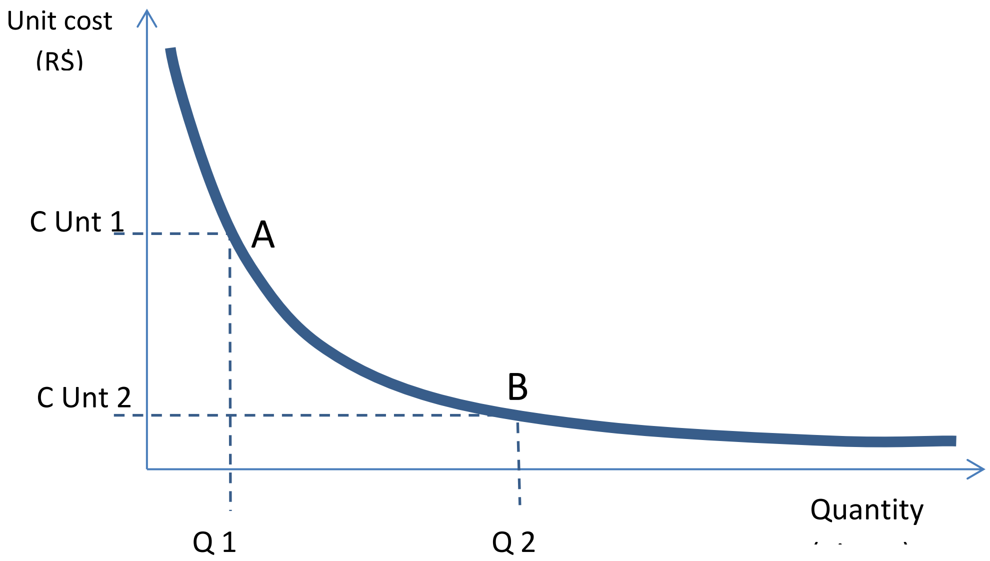


Source: Adapted from Slack, Chambers, Johnston (2009, p.93).

It should be noted that the reduction of the output variety is necessarily due to the increase in output volume (production). In this way, the decision maker in the manufacturing industry needs to identify the variety and the volume of output that is sought to decide only on the most appropriate production process to be implemented in the company.

Another important observation about the traditional productive systems is the relation of the alternatives described previously with the gain of scale curve, which is presented in Figure 5.

Figure 5 – Scale gain curve



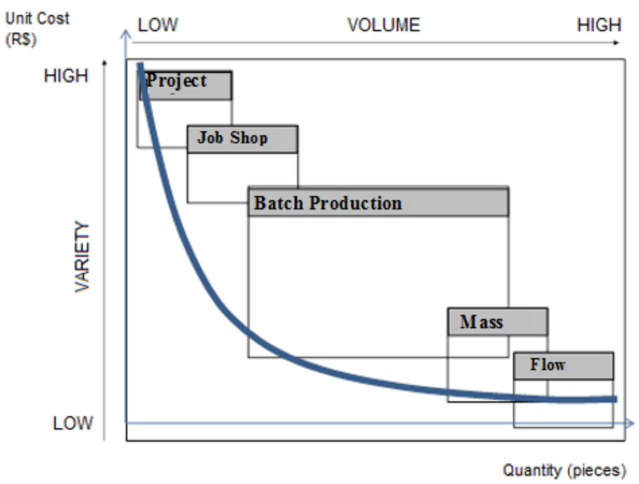
Source: Author's own (2016).

The scale gain curve relates the unit manufacturing cost to the produced volume (output volume).

Point A of Figure 5 demonstrates that low production volumes provide a high unit cost of manufacturing a product. Point B, on the other hand, has a high volume of production and, therefore, a low unit production cost.

The simultaneous analysis of the production systems (Figure 4) and the scale gain curve (Figure 5) is shown in Figure 6.

Figure 6 – Simultaneous analysis



Source: Author's own (2016).

The comparison developed in figure 6 allows us to understand the difficulty of achieving batch manufacturing in low volumes at a low cost, since the logic of the gain of scale presupposes the production of large volumes of products in order to reach reduced costs, as can be seen in continuous (and uninterrupted) systems of production.

2.4.2 Flexible automation

Also known as Programmable Automation, it deals with situations where it is relatively easy to change the sequence of operations. Using electronic technology and microelectronics, the sequence of operations can be changed via a computer program that controls the movement or functions of the work environment. Flexible automation can be suggested to be achieved by coupling machines with computers and computing.

Monteiro (1998) considers that flexibility is the ability of a Manufacturing System to master changes effectively. Regardless of size, automation level, or other factors, a manufacturing system is considered flexible only when one or more of its components have desirable physical attributes, such as the ability to process different types of parts / components, rapid responses, multiple routines and variety of controls.

Advances in manufacturing systems, as well as automation, have given rise to Flexible Manufacturing Systems (FMS). The FMS uses CNC-driven machines and an Automated Materials Handling and Transport System under the supervision of an integrated computer control system. This technological contribution allows to minimize the time of machine preparation (setup) allowing the manufacture of batches of reduced sizes in an economical manner.

FMS has been heavily used in the industry from the increasing consumer demand for a greater variety of products and, consequently, smaller lot sizes. This required a highly technological solution to reconcile the innovations of integrated manufacturing with the benefits of process standardization, automation and robotization. This set of technological solutions allows the reduction of manufacturing costs, even making a high number of stops for tool changes.

2.5 Changes in Supply-chain

Supply chain is defined by Mentzer et al. (2001) as being the set of three or more organizations directly involved in the upstream or downstream flows of products, services, financial and information, from the primary source to the final customer.

Companies participating in the supply chain must demonstrate the ability to meet new market demands, such as managing a wide variety of products, competence to process small lot sizes, ability to distribute products across different channels, and ability to place products in the market in in the market capillarity.

Strongly related to the movement and storage of raw materials, Work In Process (WIP) and finished products, the supply chain has evolved over time in order to minimize the costs of these activities.

Such improvements are due to practices as cargo consolidation, routing, Economic Order Quantity (EOQ) and Economic Production Quantity (EPC) studies, facilities location, warehouse and distribution centers sizing, as well as the simulation methods.

With the advent of internet technology (Internet Protocol - IP), products that once had a strong need for transport and storage activities such as CDs / DVDs, books and documents, are now digitally transferred from suppliers to customers through the telecommunications network, reducing the flow of goods in the supply chain.

Industry 4.0 proposes, among other innovations, the intensification of rapid prototyping technologies (3D printers). Like previous examples, 3D printing enables a drastic reduction in the flow and storage of finished products, since many products will be generated at the point of sale, that is, before the eyes of the customers, minimizing the pressures for activities logistics in the supply chain.

Final considerations

In this essay some aspects of Industry 4.0 and their impacts on operations processes were presented. With the dissemination of technologies, these processes will undergo profound changes or even lead to new processes that will allow the production of small, even unitary, low cost and flexible packages to easily customize the products.

In this way, we live in a rupture innovation environment, bringing a great leap of technological development.

Other aspects, such as impacts of new materials, mergers of knowledge areas, relationships between labor, machines and companies, are themes for future work.

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