EasyChair Preprint

№ 4703

The Emergence of New Business and Operating Models Under the Industrial Digital Paradigm Industrial Internet of Things (IIoT), Platforms, and Artificial Intelligence/Machine Learning (AI/ML)

Federico Walas Mateo and Andres Redchuk

December 7, 2020

The emergence of new business and operating models under the Industrial Digital Paradigm

Industrial Internet of Things (IIoT), Platforms, and Artificial Intelligence/Machine Learning (AI/ML)

Federico Walas Mateo[1], Andrés Redchuk[2]

[1] Universidad Nacional Arturo Jauretche, UNAJ, Florencio Varela (1888), Buenos Aires, Argentina
[2] Universidad Nacional de Lomas de Zamora. Facultad de Ingeniería. Buenos Aires, Argentina. ETSII Universidad Rey Juan Carlos. Madrid. España.

Abstract. This paper pretends to approach and analyse opportunities and risks that arises under the Industrial digital paradigm. Known by different names like Industry 4.0, Smart Manufacturing, or Production 4.0, among other terms digitalization in industry is advancing at a tremendous speed, and is pushing stablished firms to change and adopt new tools. Besides it opens opportunities to technological startups to deliver new products and services to the industrial market.

As an example of opportunities in operating models, it is clear that digitalization under the model Industry 4.0 and the advantages of Industrial Internet of the Things (IIoT), allows faster response to customer demands, increase flexibility allowing the adaptability to manufacturing processes, and provides a tremendous amount of tools for quality improvement in the processes, among other advantages.

This article addresses the data driven organization as digitalization evolves and the progress of Artificial Intelligence (AI) and Machine Learning (ML) solutions for industry.

Keywords: Industry 4.0, Industrial AI/ML, Data driven management.

1 Introduction

This work approaches one of the edges that shows the Industry 4.0 paradigm, and aims to explore opportunities and challenges that arise from its adoption, transforming traditional value chains to facilitate the creation of value and reach new levels of competitiveness.

The fourth industrial revolution, commonly termed as industry 4.0, is not just about industry. It is about overall transformation using digital integration and intelligent engineering. It is quoted as the next level of manufacturing where machines will redefine themselves in how they communicate and perform individual functions (Muhuri et al. 2019).

Another point of view about Industry 4.0 is given by Ibarra et al. (2017), according this work the new model has been brought into the manufacturing world by the increasing fusion of Industrial Production and Information and Communication Technologies (ICT). This phenomenon is making possible to connect information, objects and people due to the convergence of the physical and the virtual (cyberspace) worlds in the form of Cyber-Physical Systems (CPS). Therefore, it is enabling the transformation of factories into smart environments.

Sarmiento et al. (2020) stablish that a key principle of the Industry 4.0 paradigm is that processes and machinery must be networked as a collaborating community for the collection, exchange and analysis of data in order to predict future behaviours and pursue optimal solutions to possible problems. In the paper the author considers that nowadays, this principle is beginning to be achievable thanks to the development of a number of promising technologies. One of these technologies is the so-called Cyber–Physical Systems, which refers to systems with integrated computational and physical capabilities that can be interfaced in different ways. These systems are enhanced with features from the Internet of Things (IoT) technology, providing them with the ability to continuously obtain information from sensors or processes across the factory, and securely forward it to (generally cloud-based) data centres. This massive data production implies the development of new tools based on Big Data techniques, for storing, managing, and processing it. This set of technologies is completed with the Internet of Services (IoS) one, which takes the processed information from Big Data tools and deploys it at the right place and in the right form.

IoT is referred more specifically as Industrial Internet of Things (IIoT) when referred to its adoption in Industry. Porter and Heppelman (2015) uses the concept of IIoT and describes the way it makes possible to connect devices and obtain data from reading the devices. In the same work is explained that linking combinations of readings to the occurrence of problems can be useful, and even when the root cause of a problem is hard to deduce, those patterns can be acted on. Data from sensors that measure heat and vibration, for example, can predict an impending bearing failure days or weeks in advance. Capturing such insights is the domain of big data analytics, which blend mathematics, computer science, and business analysis techniques.

This paper pretends to go further from previous work regarding opportunities and risks that arises from digitalization, and specifically at the Industry 4.0 model and the emergence of new business models, Walas Mateo (2020). This paper pretends to go

deeper into opportunities around solutions on IIoT, platforms, and Artificial Intelligence/Machine Learning (AI/ML).

2 Conceptual Framework

To start the discussion of the subject it is aimed to approach, the definition de business operating model and business model by Iansity and Lakani (2020) it is put on consideration. The authors define that the value of a firm is shaped by these two concepts. The firm's business model, defined as the way the firm promises to create and capture value. The firm's operating model, defined as the way the firm delivers the value to its customers.

Searching for the drivers of competitiveness in digital business models under Industry 4.0 model, Grover et al. (2018) considers big data as a new yet powerful source for potentially immense economic and social value and for gaining a competitive advantage on par with an organization's capital assets and human talent. In this article it is affirmed that according to a 2016 report from PromptCloud, big data has grown from a $6.8 billion industry to a whopping $32 billion industry in just three years. IDC forecasts the market of big data technology and services to grow at a 23.1 percent compound annual rate, reaching $48.6 billion in 2019.1 Therefore with the volumes of organizational data moving past terabytes to tens or even hundreds of petabytes, businesses and information technology (IT) leaders are embracing unique opportunities to capitalize on big data to gain the competitive advantage. It is also considered in this article that companies are reported to spend more than 10 percent of their IT budget on data alone and are undergoing a revolution by leveraging big data and analytics (BDA) as a strategic asset to guide their decision-making and improve business processes and outcomes.

An interesting article about the evolution of Artificial intelligence (AI) is brought by Thomas Davenport (2018). In this work he states that analytics 4.0 is the next step in analytical sophistication for organizations, and it is the era of artificial intelligence or cognitive technologies. It became widely adopted – with adoption rates, depending upon geography, of 20 to 30% across large enterprises in 2016 and 2017. It features not only the use of AI methods, but also greater use of autonomy in the execution of the methods, particularly automated machine learning (ML).

A recent article by Davenport (2020), which is based on a research by Deloitte on the use of AI tools in Industry highlights how barriers to the adoption of artificial intelligence tools have decreased. Based on a survey of more than 2727 global executives from nine countries, and their organizations have all adopted AI. The key facts that emerge from the article is that the respondents feel that AI is getting easier, and will continue to do so.

Then there are two interesting insights from this article. The first one, is the preference for buying ready-made AI technology over building it. Indeed, at some point it will be difficult not to buy. Another item points that 74% of these executives agreed that "AI will be integrated into all enterprise applications within three years." In terms

of today's practice, 50% say they will either "buy all" of their AI capabilities. The second, is about the risks the adopter see about AI. Some of the specific risks that most concerned respondents were cybersecurity issues, AI failures that might affect business operations, misuse of personal data, and regulatory changes involving AI/ML.

Iansiti & Lakani (2020) conceptualize the Artificial Intelligence (AI) Factory as the core of the modern firm, where it is industrialized data gathering, analytics, and decision making. The AI factory is the scalable decision engine that powers the digital operating model, where value is created, of the twenty-first-century firm. Managerial decisions are increasingly embedded in software, which digitizes many processes that have traditionally been carried out by employees. Digital operating models can take various forms, AI factories are at the core of the model, guiding the most critical processes and operating decisions, while humans are moved to the edge, off the critical path of value delivery. From the concepts of these authors two points should be considered in this paper. The first one is transforming the industrial environment to an AI Factory environment, and the second one is the new role of the industrial operator or the industrial engineer.

A concept that needs to be consider when talking about new business models under Industry 4.0 paradigm is uncertainty. To cope with this fact, sensing and rapid response when planning a new strategy is critical. A tool that could help to develop and find a product and business model that really works is an Agile methodology called Lean Start Up. The real challenge is to develop and validate the value proposition, and look for a profitable business model that allows to consolidate sales and scale the volume of business.

The Lean Start Up methodology created by Eric Ries (2010), collecting the adjective "lean" widely disseminated when describing production methods developed by Toyota and other Japanese manufacturers for dispense with everything that is left over, hinders and lengthens the Productive processes. The fundamental objective of Lean Startup is shortening the product development cycle and employing agile development methods, with validation tests by the market, to match the processes to the acceptance of the clients, adjusting and pivoting -when needed-Indicators are used incremental to measure the result of the actions on the interested customers and sales and the model is analysed and controlled appropriate growth based on acquisition costs, of customer retention and the value of customers throughout its life cycle. In sum, a set of techniques for match the product development processes with the customer discovery and development.

A last issue to consider is what Ibarra et al. (2017) mention about the effects of the phenomenon considered as the Fourth Industrial Revolution. In the paper by this author is stablished that it will be the most powerful driver of innovation over the next few decades triggering the next wave of innovation. Thus, the main features related to the Industry 4.0 such as real-time capability, interoperability and the horizontal and vertical integration of production systems through ICT systems, are regarded to be the response to current challenges that companies must face to stay competitive in terms of globalization and intensification of competitiveness, the volatility of market demands, shortened innovation and product life-cycles and the increasing complexity around products

and processes. The adoption of data models, especially when working with heavy industries where is not possible to change to last generation equipment and machines, and digitalization could help to improve the performance of assets with decades in use in steel or energy generation industries.

3 Objective of the work, hypothesis of the research

Having enough evidence about the use and benefits of data analytics in the productive environment under Industry 4.0 framework, this work it is aimed to study and analyse opportunities and difficulties that arise to create new business and operating models from the use of IIoT, Artificial Intelligence and Machine Learning in the industrial environment to improve industrial processes.

This paper aims to take in consideration the issues in the above paragraphs, in the framework of the adoption of IIoT and AI/ML solutions. A key topic to explore is how open innovation, Lean startup and platforms, among other methodologies can help with the challenge that means the disruption that is produced in the industrial scenario when adopting data models.

A paper of the Boston Consulting Group (2015), states that the model Industry 4.0 allows faster response to customer demands, increase flexibility allowing the adaptability to manufacturing processes, and provides a tremendous amount of tools for quality improvement in the processes, among other advantages.

Another observation that is object of this work is what is said by Muhuri et al. (2019) about studies that have shown that digitization of products and services has become a necessity for a sound industrial ecosystem. However, these requirements and advanced technologies have made the systems more complex and led to many other challenges such as cybersecurity, reliability, integrity, etc. These are the major bottlenecks which needs to be overcome for the successful design and deployment of Industry 4.0.

This work aims to approaches one of the edges that shows the Industry 4.0 paradigm, and to explore opportunities and challenges that arise from its adoption, transforming traditional value chains to facilitate the creation of value and reach new levels of competitiveness.

4 Some interesting findings

Iansiti & Lakhani (2014) establish in their work that adapting to ubiquitous digital connectivity is essential to competitiveness in most sectors of the economy. They reinforce the concept by saying that they have examined transformation across dozens of industries and companies—both traditional and born-digital, talked to hundreds of executives in an effort to understand how traditional modes of innovation and operational execution are changing. (Disclosure: they have consulted with or have interests in several of the companies mentioned in their article.) They have seen that digital transformation is no traditional disruption scenario: The paradigm is not displacement and replacement but connectivity and recombination.

The concept product as a service has broaden to anything-as-a-service (XaaS). An article from Deloitte, by Sharma et al (2019) suggest that the ever-changing technology landscape—currently shaped by technologies such as cloud computing, anything-as-a-service (XaaS), and the Internet of Things (including industrial IoT)—has solidified the need for businesses to adopt a customer-in mindset, shifting focus from selling a product to nourishing a customer relationship: understanding expectations and maximizing customer value from offerings.

Walas Mateo (2020) give a brief description of how the robotic industry is changing business models through connected products with the case of Universal Robots (UR). Today it is possible for UR industrial robots and other robots suppliers to implement as a service business models to facilitate any firm to afford having a robot. Beyond that UR introduced the concept of collaborative robot or cobot, making possible human and robots to work very close each other in the industrial environment.

In this work Walas Mateo (2020) points that there are three different kind of disruptive business models, some of them derivate from digital transformation, economy of platforms, decentralized models or superfluid economy. The new business models and the companies that represent them lean on a series of repeating premises: personalization, pay per use, collaborative model, agile and flexible organizational models, and the data.

The paper of the BCG (2015) approach the cooperation in Industry 4.0 where companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data integration networks evolve and enable truly automated value chains. In this line, it is presented an example of how Dassault Systemes and BoostAeroSpace launched the platform AirDesign, for the European aerospace and defense industry as a common workspace for design and manufacturing collaboration. This platform is available as a service on a private cloud. In this way it can be managed the complex task of exchanging product and production data among multiple partners.

Iansiti & Lakhani (2020), refers to platforms and their integration that allows an effect of extraordinary scope when talking about digital operating systems, allowing disruptive business and work models. The authors especially mentions Alibaba and Amazon cases. A platform is an environment where an application runs, and based on network connectivity, this definition has been extended to a space where different users can interact with each other or with physical objects. As a result, suppliers, customers, and other partners become part of a networked ecosystem around the CPS.

The integration and scope of the platforms are generated by being connected through APIs. An API, an acronym for Application Programming Interface, is the mechanism that allows devices and platforms to be integrated. It is something that facilitates, for example, that applications using georeferencing to access information from Google Maps.

This phenomenon of liquid marketplace, as it is called by Iansiti & Lakhani (2020) from the possibility that generates Internet and ubiquity, makes possible to reconfigure global value chains, and integrate different platforms to make easier operations management.

In line with this Walas Mateo (2020) presents the case of the European network of Kiala that count on 7,200 Points and 1,050 Click & Collect Points distributed in 5 European countries. In this way the company offers a delivery service without a single drop-off or pick- point in a building of its own. This is an example of a new level of liquid business that is becoming increasingly common.

An interesting view regarding innovation, platforms, and digital disruption is brought by Cozmiuc, & Petrisor (2018) they say that business models have become key to digital disruption, and the latest business models shift from pipeline material flow to knowledge creation in platforms. They remark the importance of open innovation as part of platform business models, and that business models are now financed directly, which has created the lean startup movement. Startups enter markets with no barriers and force incumbents to race them with the ability to compete based on business models and match start-up agility and creativity. In this work they describe the case of the world's top innovators, Siemens, and the way the company uses the latest tools for innovation: open innovation for technology invention, business models to turn invention into innovation, and finances business models. Siemens has created an inner structure that intends to bring the advantages of the lean start-up movement indoors.

In the framework of what is described above, arise the Siemens Next47 initiative. According to Hilse & Susemihl (2018) in their work on successful cooperation between companies and startups, develop the case extensively. It is an accelerator of technological startups with products and services for IIoT, AI/ML, and other disruptive digitization solutions.

In Gradient Ventures, Google's AI-focused venture fund investing in and connecting early-stage startups with resources in artificial intelligence. Searching in its portfolio of startups founded, Canvass Analytics, www.canvass.io, is one of them. This startup that aroused interest for this research had developed a business model based on an AI-powered predictive analytics platform for Industrial processes. Its customers include leading manufacturing and energy companies globally.

At its web site the startup says that its platform automates the entire data science process, eliminating consulting data science projects. They affirm that the platform approach has accelerated the time to insights 12 times faster than other solutions and approaches. The solution is developed specifically for the industrial sector.

A paragraph in the findings deserves the importance of the Customer when adopting a new business model. Cornella & Planellas (2020) conclude in their work that customers will also be part of the company, especially those who prove to be the best 'sensors' for real demand.

At the end, it should be considered the success in adoption of the new models. An interesting aproach is given by Sailer (2019) in a paper where it is stated that it has been identified three key imperatives in successful digital transformations. These imperatives have shaped their Integrated Change Management methodology:

- Instituting an integrated approach across facts – i.e., tangible elements such as technology, processes and social interactions – i.e., intangible elements such as culture and teams throughout the transformation journey and across the entire company.

- Living agile by proactively updating change measures to meet both current needs and overall objectives effectively
- Adapting “classic” Change Management levers such as communication, leadership, team setup, training, etc. for digitalization needs

5 Conclusions and future work

Different firms in a broad spectrum of sectors are shifting value from manufacturers and distributors to companies that operate end-to-end platforms and provide outcomes as-a-service. Many firms face growing threat of market obsolescence, and then constant change seems to be the golden rule.

Regarding the role of the customer and operators in the shop floor, seems people have a central role in new operating and business models. It can be said that each new opportunity will require the participation of people and departments who are today isolated in their silos, and so creating multidisciplinary teams. Collaboration with other companies will be the norm once it is understood that the world is too complex to be solved in isolation.

A point to consider when thinking in new operating or business model in any firm, is the need for agility. A Lean startup approach to test the new model and go for a fast ROI seems a good option.

This paper left some questions to be studied in future work. The first one in this line of research, is the data driven organization as IoT evolution from leading edge innovation mainstream technology and its business potential. Also very important is to watch the progress of Artificial Intelligence (AI) solutions for industry, such as those presented by new technological startups. New firms appear everyday to provide tools for smart manufacturing environments, capturing and delivering value in Industrial environment. New companies like LLamasoft, which provides AI for supply chain management (SCM), and the mentioned before in this paper, Canvass Analytics are examples of this dynamic.

Another key topic to explore in future work, is how process operators or industrial engineers can cope with the challenge that means the disruption that is produced in the industrial scenario when adopting data analytics models. Therefore the question is the way the shop floor will capture the value that generates the AI/ML, should the process operator or industrial engineer at the process level go further in the master of analytics tools, or the solutions that managers should buy according to Davenport (2020) will be tuned to the language and needs of the people that work in the process.

Finally, another issue that awake curiosity regarding AI/ML as process optimization driver is the integration with IoT and its evolution from leading edge innovation mainstream technology, and potential to produce data to feed AI/ML models.

6 Acknowledgments

The authors wish to thank two research projects that made possible the content of this article. The projects are "Análisis del abordaje de herramientas de Producción 4.0 en PyMEs locales", approved by Resolution (R) No. 148-18- UNAJ INVESTIGA 2017 Program, and “Mejora de Procesos, Optimización y Data Analytics: Aplicación en Procesos e Industrias de Interés Regional Mediante Estudios de Casos Reales”, approved by Resolution Res. Engineering Faculty C.A. 001 – 12/02/2019.

7 References

1. Boston Consulting Group. (2015). Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries.
2. M. Iansiti, K. Lakhani. (2014). Digital Ubiquity: How Connections, Sensors, and Data Are Revolutionizing Business. Harvard Business Review. Nov. 2014
3. P. Sailer, B. Stutzmann, D. Kobold. (2019). Successful Digital Transformation How Change Management helps you to hold course. Siemens IoT Services. Copyright © Siemens AG. Oct 2019
4. D. Sharma, J. Gill, A. Kwan. (2019). Customer-centric digital transformation. Deloitte Insights. Sept 2019
5. A. Cornella, M. Planellas. (2920). The (Im)Possible Transformation: how to transition a company to a new operating system. Institute of Next by Infonomia.
6. M. Iansiti, K. Lakhani. (2020). Competing in the age of AI: strategy and leadership when algorithms and networks run the world / Boston, MA: Harvard Business Review Press.
7. M. Porter, J. Heppelmann. How Smart, Connected Products Are Transforming Companies. Harvard Business Review. Oct. 2015
8. T. Davenport (2020). Is AI Getting easier?. Forbes Media LLC.
9. McKinsey (2011). Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute. In
10. D. Ibarra, J. Ganzaraina, J. I. Igartua. (2017). Business model innovation through Industry 4.0: A review. 11th International Conference Interdisciplinarity in Engineering, INTER-ENG 2017, October 2017, Tirgu-Mures, Romania.
11. J. R. Ruiz-Sarmiento, J. Monroy, F. A. Moreno, C. Galindo, J. M. Bonelo, J. Gonzalez-Jimenez. (2020). A predictive model for the maintenance of industrial machinery in the context of industry 4.0. Engineering Applications of Artificial Intelligence 87 103289
12. F. Walas Mateo. (2020). Industry 4.0 and the emergence of new business models. LACCEI 2020. The Eighteen LACCEI International Multi-Conference For Engineering, Education Caribbean Conference For Engineering And Technology. Buenos Aires. Argentina.
13. E. Ries. (2010) Lean Start Up. Crown Publishing Group
14. D. C. Cozmiuc, I. I. Petrisor. (2018). Handbook of Research on Strategic Innovation Management for Improved Competitive Advantage Volume 2, Pages 477-497 Innovation in the age of digital disruption: The case of Siemens (Book Chapter). 13 April 2018.
15. H. Hilse, I. Susemihl. (2018). Erfolgreiche Kooperationen von Corporates und Start-ups. Organisations Entwicklung Nr. 1.
16. P. K. Muhuri, K. Shukla, Amit, A. Abraham. (2019). Industry 4.0. A bibliometric analysis and detailed overview. Eng. Appl. Artificial Intelligence 78, 218–235.

17. T. H. Davenport (2018). From analytics to artificial intelligence, Journal of Business Analytics, 1:2, 73-80, DOI: 10.1080/2573234X.2018.1543535.
18. P. Sailer, B. Stutzmann, D. Kobold. (2019). Successful Digital Transformation. How Change Management helps you to hold course. Siemens IoT Services. Copyright © Siemens AG. Oct 2019