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Business Information Systems in Industry: The Supplier Perspective

1. Introduction

"Originally initiated in Germany, Industry 4.0, the fourth industrial revolution, has attracted much attention in the recent literature. It is closely related with the Internet of Things (IoT), Cyber Physical System (CPS), information and communications technology (ICT), Enterprise Architecture (EA), and Enterprise Integration (EI)"[2]. The path until this new paradigm has been long. It started by the end of the 18th century with the first industrial revolution. In figure 1 it is possible to find a brief overview of the industrial revolutions.

According to Acatech[3],cyber-physical systems are systems with embedded software that through the utilization of sensors perform a direct physical data record that will interact both with the physical and digital world. This interaction is only possible due to the inter-connections among those systems. Those inter-connections are ready to use globally available data and services. "The result of the connection of embedded systems with global networks is a wealth of far-reaching solutions and applications… Subsequently, innovative business options and models are developed on the basis of platforms and company networks. Here, the integration of the special features of embedded systems – for example, real-time requirements – with the characteristics of the internet, such as the openness of the systems, represents a particular technical challenge"[4].

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2 L. Yang, *Industry 4.0: A Survey on Technologies, Applications and Open Research Issues*, "Journal of Industrial Information Integration" 2017, in press.

3 Acatech, *Cyber-Physical Systems Driving force for innovation in mobility, health, energy and production acatech POSITION PAPER*, Springer Verlag, Berlin 2011.

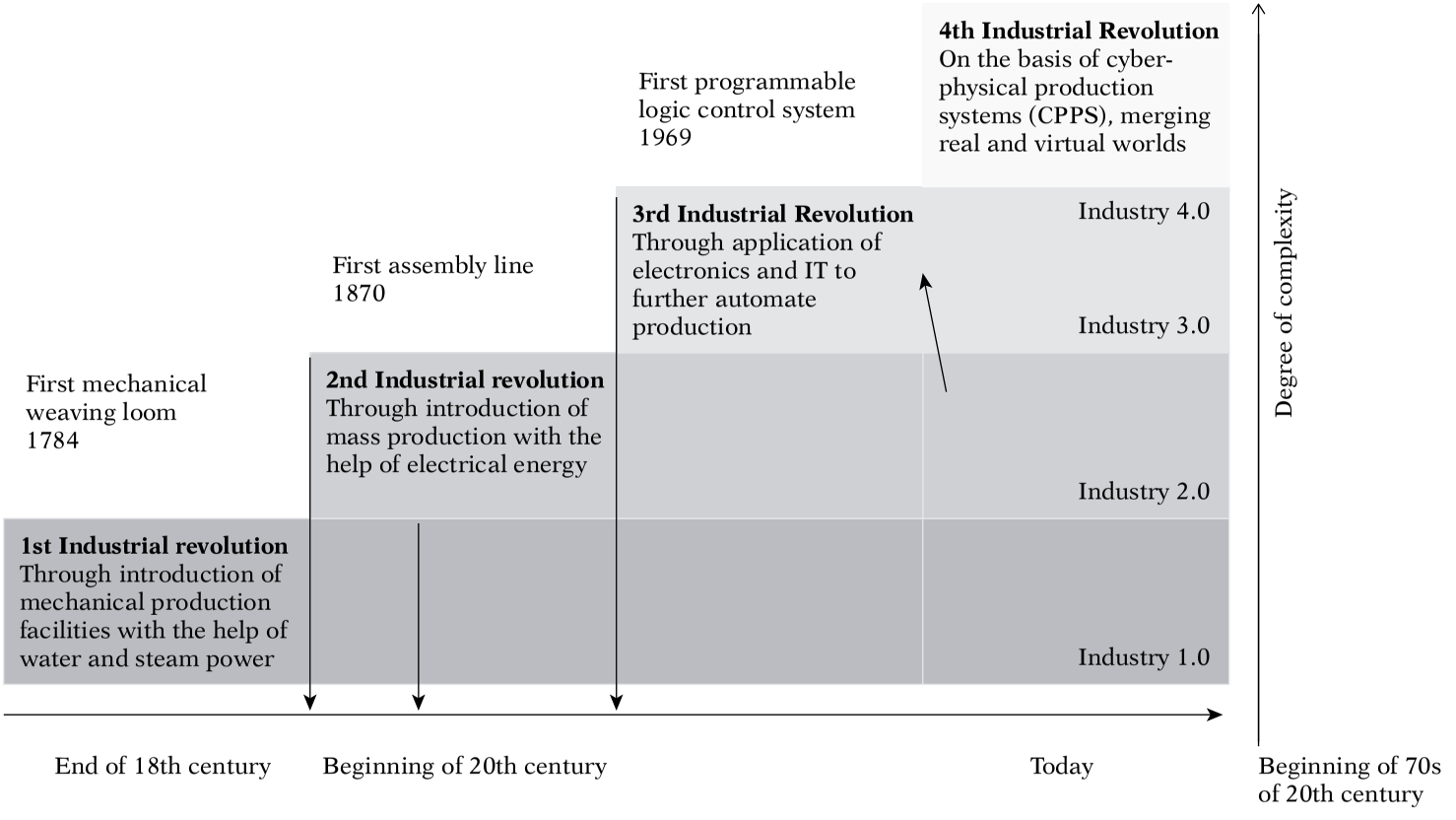

Figure 1. Definition of Industry 4.0

Source: Adapted from Schlick, Stephan, & Zühlke, 20123.

This new way of production is a revolution in the manufacturing industry. "Connectivity and interaction among parts, machines, and humans will make production systems as much as 30 percent faster and 25 percent more efficient and elevate mass customization to new levels"[4]. However, according to Zhang & Tao[5], in the traditional manufacturing process, it is hard to achieve real-time production scheduling due to the lack of real-time information on the shop floor.

This new approach to production systems is in fact very interesting, but there are some questions about the way firms will face it. Are firms fully engaged in this process? Are firms implementing the necessary systems to make it work? Are firms using the information and aligning the resources to promote efficient information analysis? This paper results from some conversations with SMEs IT suppliers. It aims to be a preliminary study in order to identify the 4.0 tendencies and weaknesses in the region of *Tâmega e Sousa*, an industrial region located in the north of Portugal.

2. Literature Review

E. Ngai, S. Peng, A. Alexander, K. Moon[6] presented a literature review on the application of decision support and intelligent systems in textile industries. First of all, they identified that those systems are applied at different levels according to the subsectors. Some of those subsectors attract less attention. The exploitation of using artificial intelligence technologies may be helpful in improving the performance of the forgotten areas and, in turn, benefitting all the sectors along the supply chain. According to the authors, most of the applications of decision support and intelligent systems are confined to certain individual function areas. Artificial intelligence technologies can offer advantages in managing information flow. This is an important factor in enhancing supply-chain integration. Greater use of those technologies will turn easier to handle communication and

[4] M. Rüßmann, M. Lorenz, P. Gerbert, M. Waldner, J. Justus, P. Engel, M. Harnisch, *Industry 4.0 The Future of Productivity and Growth in Manufacturing Industries*, Boston Consulting Group 2015.

[5] Y. Zhang, F. Tao, *Real-Time Information-Driven Production Scheduling System*,in: *Optimization of Manufacturing Systems Using the Internet of Things*, 2017, pp. 147–163, in academic press.

[6] E. Ngai, S. Peng, P. Alexander, K. Moon, *Decision support and intelligent systemsin the textile and apparel supply chain: An academic review of research articles*,"Expert Systems with Applications" 2014, 41(1), pp. 81–91.

share relevant information among all members, making a true integrated supply chain possible. Thus, competitive advantages can be created for the entire supply chain, instead of focused on individual subsectors with suboptimal aggregated performance.

Information assumes a key role in the optimizing processes under Industry 4.0. A good decision-making process is related to the supply chain visibility along with a better information flow and depends on the processing structures. These elements cover not only the supply chain but also the value chain (starting and ending at the customer level). The best production control systems (for decision-making) vary according to the size of the firm and the production variety. But how do small firms deal with information management, reporting and analysis?

"To acquire relevant feedback, decision makers, senior operations managers, and field workers need accurate and timely data, enabling rapid decision-making in the event of any interruptions in production. Therefore, data collection is a key component in ensuring the success of production management. However, most data collection systems are heavily reliant on paper forms, resulting in high costs, questionable accuracy, and long turnaround times […] This restricts the opportunity for timely decision making, and problems are not properly recorded at the time they occur"[7].

Another problem related to information may occur during the production process: the lack of information. Firms that do not collect relevant information for decision-making clearly act without a strategy. Focusing on firms that collect some kind of information, the process can also present inaccuracies: (1) on the shop floor, (2) finished goods, (3) inventory, or on external information such as (4) customer demand information. Those inaccuracies might lead to delays in decision-making or cost increases (such as stock level increases). In order to minimize these mistakes, some manufacturers/managers adopt a shop-floor observation policy.

Information can also be identified as a problem when it is too much. According to Gong, Yang, & Wang[8], the amount of information in a production control system can lead to delays in decision-making. The authors cited above compared the decision-making time delay among three production control systems across identical organizational structures for information processing. They conclude that

[7] J. Park, *Evaluating a mobile data-collection system for production information in SMEs*, "Computers in Industry" 2015, 68, pp. 53–64.

[8] Q. Gong, Y. Yang, S. Wang, *Information and decision-making delays in MRP, KANBAN, and CONWIP*, "International Journal of Production" 2014.

the production control system with the smallest amount of information spends the least amount of time in decision-making."With the use of the IoTs, business operations are becoming more agile and connected. Also, the data and information produced through the IoTs is used to generate knowledge that is ultimately employed to monitor and control business network operations. The companies that utilize the links between the IoTs and dynamic data and information processing capabilities achieve a better competitive advantage; they do so because their daily business operations become more agile as a result of these developments in their IT infrastructures"[9]. In order to get the best decisions based on the collected information, business information systems play a crucial role. According to Ladley[10], the bottom line for an enterprise information management programme, which must be reinforced from time-to-time, is supporting the business with clear, documented, and effective data and information. The business user needs this as badly as anyone in information technology.

Even identifying information and information systems as important actors for the decision-making process, it is not easy to manage both of them. "A key characteristic of the software applications supporting manufacturing business processes is their heterogeneity. This is due not only to differences in their development and deployment, but also to the variety of processes and actors in complex organizations. Heterogeneity at the semantic level is one of the major problems in any process of interoperability and/or integration"[11]. Not only the heterogeneity of the applications, but also the increasing heterogeneity of production pose new challenges to get the necessary information in a pattern that allows reports generation. "Due to the effects of mass-customization, there is an increase of the variance of products combined with a reduction of the number of units per variation. Therefore, it is necessary that the next generations of production lines, especially the assembling devices, have to be designed more adaptable. Regarding business information systems this trend is realized by an increasing digital integration of the particular units"[12].

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[9] P. Akhtar, Z. Khan, S. Tarba, U. Jayawickrama, *The IoT, dynamic data and information processing capabilities and operational agility*,"Technological Forecasting and Social Change" 2017, in press.

[10] J. Ladley, *The Asset Called Information*, in: *Making EIM Enterprise Information Management Work for Business*, Elsevier 2010, pp. 1–12.

[11] I. Arab, P. Millet, V. Botta, *A business repository enrichment process: Case study for manufacturing execution systems*, "Computers in Industry" 2017, 89, pp. 13–22.

[12] M. Scholz, S. Kolb, C. Kästle, J. Franke, *Operation-oriented One-piece-flow Manufacturing: Autonomous and Smart Systems as Enabler for a Full-meshed Production Network*, "Procedia CIRP" 2016, 57, pp. 722–727.

As a final remark one can use the idea presented by Chen & Xing[13]: The next stage of development is an era of integration of traditional manufacturing industries and smart technology. It is imperative to promote the development of key technologies and intelligent manufacturing as well as strengthen skilled personnel training, especially for SMEs. Since Industry 4.0 is still at an early stage, it is unadvisable to pursue it blindly and exaggerate its significance for the manufacturing industry. Most small manufacturing firms lacking innovation are at the mid-low end of the value chain. Several issues must be resolved, such as setting and implementation of the industry standards, device protocol and information sharing schemes, in order to start to prepare those firms for Industry 4.0 or IoT.

3. Case Study: The Perspective of Two Industry IT Suppliers

3.1. The Region

The study was carried in the region of *Tâmega e* Sousa, in Portugal. This region is composed of 11 *Concelhos*[14], composing the community of *Tâmega e Sousa*.

For statistical purposes this region is within NUTE III. The region has an area of 1,830 km^2 and a population of 434,165 inhabitants. A characteristic element of the region population is its predominantly rural integration: the people who live in towns with more than 2,000 inhabitants do not even reach one third of the population, when the regional and national average exceeds 60%[15].

According to Castro et al., the manufacturing industry is the main economic activity of *Tamega e Sousa*. The 4,700 industrial companies based in *Tâmega e Sousa*, have employed 53,745 people and generated a Gross Value Added (GVA) of € 722 million for a turnover of € 2,372 million in 2011. These figures correspond to 40% of people employed in companies of *Tâmega e Sousa*, 41% of GVA and 36% of total turnover. In 2011, labour productivity in the *Tâmega e Sousa* industry was equal to € 13,437 per person employed, which corresponds to two thirds of the total registered in the North industry and 54% of the domestic industry.

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[13] Z. Chen, M. Xing, *Upgrading of textile manufacturing based on Industry 4.0.*, in: *5th International Conference on Advanced Design and Manufacturing Engineering 2015*, pp. 2143–2146.

[14] *Concelho*: Portuguese administrative unit divided into smaller units called *freguesias*.

[15] A. Castro, V. Rodrigues, A. Vilaverde, F. Gonçalves, J. Silva, L. Sopas, M. Ferreira, M. Sottomayor, S. Costa, *Plano Estratégico de Desenvolvimento Intermunicipalda Região do Tâmega e Sousa*, 2014.

In this region it is also possible to find some industrial districts, such as shoe making in *Felgueiras*; textiles in *Lousada*; wood furniture in *Paços de Ferreira*, and metalworking in *Amarante*.

3.2. Methodology

This is a preliminary study about business information systems in this region towards Industry 4.0. The main goal was the identification of trends; strengths or weaknesses that firms within this region are dealing with. Since this is the first approach, it was decided not to target the firms directly to collect primary data through a questionnaire. What was analysed was the use of IT in this sector, and it was verified that an overwhelming majority of firms do not have an IT department. Instead, they outsource these services. Taking into consideration this scenario, the target were the IT suppliers. The main reasons to choose this target was the low number of IT suppliers (not retailers, but those that develop software) compared to the number of firms acting in the manufacturing industry.

In order to collect relevant information for this research, an informational interview was performed[16]. This methodology can be described as informal conversations with someone working in an area under research that will provide information on that specific area. Even being the methodology oriented to job interviews and career exploitation, for the present research and considering the goals of this paper it fits with the research goals. According to Bolles[17] in the context of a career exploration there are three types of interviews: practice, informational, and job interviews. An informational interview "involves interviewing workers who are doing work a person thinks they might be interested in doing, in order to discover if they are on the right tracks"[18]. For this research people that provide IT and IS (Information Systems) solutions for manufacturing and services industries were interviewed. These suppliers know the information systems maturity level that exists in their customers' companies.

As an advantage for this research this methodology allowed:

- getting relevant information about the implementation and use of IT;
- getting tips about how to prepare a future questionnaire in terms of language and concepts familiar for those dealing with IS in firms;

[16] C. Decarie, *Literacy and informal interviews*, "Business Communication Quarterly" 2010, 73(3), pp. 306–317.

[17] R. Bolles, *What color is your parachute?*, Ten Speed Press, New York 2016.

- gaining insider knowledge of firms' IS maturity level;
- expanding the network identifying firms closer to the 4.0 age.

This approach could also be classified as a case study, but in that case the case analysed should be the supplier itself. Since the supplier is a source to collect information about other firms, this alternative methodology was identified as a good one for the present research. The next step is to organize all the information in order to prepare a questionnaire targeting the firms (users) of IS in order to identify how close or far they are from the 4.0 perspective.

3.3. Results

Bearing in mind the new approach to production processes under the Industry 4.0 perspective, and information management by managers in small firms, there was applied the methodology of an informal conversation with two IT suppliers based in this region. This geographical approach seemed to be interesting not only because of the characteristics of the region, but also because it was possible to gather information from the people that contact daily with several stakeholders from the region.

The first idea that can be drawn from those interviews is that the typical shop floor management relies on one person: the business owner. Normally the management of materials, lead-time and operations is based on observation rather than reports. In some particular sectors such as the footwear industry, production control relies mostly on the number of finished goods per day. This type of management leads to waste such as raw materials stock excess.

Another identified problem is the fact that most firms are equipped with different types of information systems, in particular ERPs. It is possible to verify that firms acquired those systems according to a specific need, and tried to get the cheapest solution at that moment. Nowadays, it is quite difficult to merge all the information in a single database. Merging problems take us to another issue: nowadays, terms like cloud storage are quite frequent, however, most firms prefer to use a system of internal servers. This option is popular due to the investment already made, the costs of clouding services, and the lack of trust in sending private information to somewhere that is outside the firm.

Considering all the identified restrictions, it is not difficult to identify the first barrier that firms will face towards the 4.0 perspective. And this barrier is in the forefront of Revolution 4.0 – information analysis and information integration. In fact, this was the main problem that one IT supplier identified. By supplying different activities' sectors, the interviewed mentioned that a large

group of business people claim a need of getting information in real time. However, this information needs to be collected from different departments, sometimes supported by different systems, some other times without digital systems. This takes us to the problem of (information) integration along the supply chain, as presented by several authors (e.g. Ngai et al., 2014; Chen & Xing, 2015; Tian & Hongtao, 2015).

What regards manufacturing, besides the integration issues, the supplier also identified a problem of organization. This occurs in particular in firms that do not identify IS as a management tool. Customer and supplier orders (mis) alignment, changes in the prioritization of production orders, or non-compliance with customers' requirements, are the most frequent consequences from the lack of organization. The interviewed suggested that business and information organization present a direct relation with business survival.

Some other issues like workforce experience, competition and relation with stakeholders were mentioned, however, the issues of integration were identified as something crucial for those firms that seek for real time information in order to perform a precise decision-making process. Advice from the experience that they gained during the time they have been providing IT solutions is that organization is crucial. From a scientific perspective, it seems that organization is clearly at the beginning of the process. Firms that are able to organize their business activities will certainly have the chance to look for something else, like information for decision-making. At this point we can call it business intelligence at lower levels.

From the conversations that were conducted it was also possible to identify that (small) firms are at most seeking for solutions that will help in business management, such as business intelligence. Solutions like cyber physical systems for the productive process are still far to reach for smaller industries.

4. Conclusion and Further Research

In the present research, which is classified as a preliminary research on the level of maturity of manufacturing firms for Industry 4.0, it was possible to identify some relevant ideas for future research. First, and from the theory, timely information is a key element for the decision-making process. Consequently, business information systems require updated data for timely decision-making. However, in SMEs a frequent scenario is the absence of this data (registration)

or when it is done, it is frequently on paper sheets, being transferred later into the information system. From the field research it was possible to conclude that in this region the typical shop floor management relies on one person: the business owner, and frequently decision-making is based on observation rather than organized information.

Another barrier that firms must overcome towards the 4.0 perspective is related to systems optimization: firms were acquiring different solutions over time, according to the specific needs at that moment. It means that not only it is difficult to collect all the important data on time, but it is also difficult to merge the information in order to get business reports – Business Intelligence Systems are not yet working properly. Prior to information integration, another issue was identified as crucial, not only to respond to the Industry 4.0 requirements, but also for firms' survival: organization. In order to get the necessary and relevant information for decision making, businesses must be organized along the supply chain activities. This culture of organization must start on the shop floor going then to the information systems. In some cases it was identified that organization is not always present in daily operations.

The next step for this on-going research is to organize all the information in order to prepare a questionnaire targeting the users of information systems (firms) in order to identify how close or far they are from the 4.0 perspective.

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Systemy informatyczne w przemyśle: perspektywa dostawcy

Streszczenie

Od czasu rewolucji przemysłowej gospodarka światowa ma do czynienia ze zmianami w sposobach prowadzenia biznesu. Najnowszym etapem rewolucji przemysłowej jest tzw. czwarta rewolucja przemysłowa (ang. *Industry 4.0*). To nowe podejście wprowadza ogromne zmiany sposobu prowadzenia działalności gospodarczej. W związku

z tym pojawiają się pytania dotyczące tejże rewolucji, która cały czas trwa. Faktem jest, że niektóre firmy już działają w środowisku 4.0, ale większość z nich to duże firmy z kulturą i zasobami, pozwalającymi uwzględnić założenia czwartej rewolucji przemysłowej. Co jednak dzieje się z mniejszymi firmami działającymi na rynku? Niniejsze opracowanie ma na celu zbadanie założeń czwartej rewolucji w przemysłowym regionie Portugalii: Tâmega e Sousa. W celu opracowania tych badań przyjęto nieformalną metodologię wywiadu. Przeprowadzono wywiady z dwoma dostawcami IT działającymi w przemyśle wytwórczym i usługowym. Zidentyfikowano, że firmy są wciąż daleko od cyberfizycznej produkcji. Dlatego w pierwszej kolejności należy zadbać o odpowiednią organizację firmy i informacji. Kolejnym krokiem (bardziej istotnym w sektorze usług, ale także wskazanym w produkcji) powinna być integracja informacji. Firmy posiadają ogromne ilości danych, ale systemy informacyjne nie są jeszcze zintegrowane i sparametryzowane w celu dostarczenia odpowiednich i terminowych informacji. W trakcie badań zbadana została również rola systemów informacyjnych w zarządzaniu jako narzędzia do wprowadzenia czwartej rewolucji przemysłowej.

Słowa kluczowe: Systemy Informacyjne, produkcja, przemysł wytwórczy, czwarta rewolucja przemysłowa.