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The "aftermath" of Industry 4.0 in Small and Medium Enterprises

João Silva¹, João Carlos Ferreira² and Frederica Gonçalves³

¹Instituto Universitário de Lisboa (ISCTE-IUL), Portugal

²Instituto Universitário de Lisboa (ISCTE-IUL), ISTAR-IUL, Portugal

³ITI/Universidade da Madeira, Portugal

silva.joao.pedro.goncalves@gmail.com

jcafa@iscte-iul.pt

frederica.goncalves@m-iti.org

Abstract. With the development of new technologies and methodologies, multiple sectors start to experience the benefits and drawbacks. Currently, the industry is facing a new revolution known as Industry 4.0. This new path allowed all enterprises to further develop their methodologies and understand the disadvantages and advantages of it. With the sole purpose of retaining costs in production while maintaining the same degree of quality, companies desire to diminish their downtime due to malfunction or improper maintenance schedules that may not amount to the desired efficiency. Nevertheless, not all companies manage to enter this exclusive circle, since such technologies also deliver a high cost which some companies simply cannot support. Consequently, this generates a huge drawback to the outsiders of this revolution.

Keywords: Industry 4.0, Cyber Physical Systems.

1 Introduction

“Companies and their industrial processes need to adapt to this rapid change if they are not to be left behind by developments in their sector and by their competitors.”[1]. Industries worldwide are becoming highly volatile, facing the same rhythms as their markets of choice. Taking in consideration the “big step” taken in industry regarding the systems being used, most companies face a problem regarding the data registered in their systems. Although it is collected, proper storage and analysis is not performed resulting in the incapability to extract viable knowledge crucial to decision making[2]. Consequently, this affects multiple areas of action such as maintenance, operations, etc. Therefore, companies must change their mindset to extract vital knowledge. This article aims to analyze the main components that lie within Industry 4.0, advantages of its implementations and understand the main differences between SME’s and MNE’s. With this research the main goal is to and answer the research question: Is it possible that the main characteristics that define SME’s justify the reason why they hold possible investments regarding the methodologies and practices inherent to this revolution?

2 Industry 4.0

Taking in consideration the developments led on during the past revolutions, a new development was needed to take full capabilities of the current information systems and produce a new output. As known, with the development of information systems in the previous revolution, data started being generated by machines in industries across the world, providing the possibility to create an automated production flow. Nevertheless, data generated was not intended to provide overall view of the production systems, more specifically to the standard maintenance point of view. Since the automation was tackled in this revolution, all the major problems regarding industry were therefore resolved. Nevertheless, the “roads” to increase earnings and productivity were decreasing. Consequently, this led to the new path of Industry 4.0. A path where the main goal was to re-shape previous ideas and concepts, allowing to reproduce models with the current technology available for industry.[3]

Throughout time this concept began to grow and became a “revolution” in 2015 propagated by Germany’s government as an action to maintain its position as the global leader in the sector of manufacturing equipment. At its core, one cannot state or identify what triggers industry 4.0. “Instead it can be described more precisely by a conjunction of many technologies -both existing and new - which now work together.”[4]. Chesworth[5] considers that industry 4.0 is the joint effect of CPS’s(Cyber Physical Sytems) and IoT (Internet of Things) therefore creating a decentralized control and advanced connectivity. Consequently, large quantities of data are generated justifying the final component of Big Data [5-7]. This joint relation constitutes the key feature of this concept, the smart factory[8].

In terms of benefits to implement the methodologies and components associated with this methodology, follows the table below (Table 1).

Table 1. Advantages of implementing Industry 4.0[6, 9]

Advantages of implementing Industry 4.0	Sector
Decrease production and logistic costs by 10-30%	Costs
Reduce Quality management costs by 10-20%	Costs
Shorter time-to-market products	Agility/Revenues
Improve customer responsiveness	Customer Experience
Mass production without increasing production costs	Efficiency
Reduce maintenance planning time (20-50%)	Efficiency
Increase equipment uptime (10-20%)	Efficiency
More confidence in data and information	Innovation
Material cost savings (5-10%)	Costs
Reduce inventory carrying costs	Costs
Reduced overall maintenance costs (5-10%)	Costs

The advantages of implementing the practices and methodologies of industry 4.0 trigger interest in all the sectors of industry, yet some already face limitations prior to generating the first step towards this new world.

3 Industry 4.0 effect in SME

“Small and Medium-sized Enterprises (SME’s) are the driving force of many manufacturing economies.”[7]. Taking in consideration their position on each country’s economy, the impacts of this latest industrial revolution are important to take in consideration. Even though these aren’t the only type of enterprises in the world, they face more challenges and limitations than Multi-National Enterprises (MNE’s). These two types of companies differ in multiple aspects as literature states. According to the European Commission [10], SME’s consist of companies with a staff headcount of 250 or less and turnover that does not exceed 50 million Euros. Nevertheless, further differences arise regarding these two types of companies. Table 2 contains the main differences regarding SME’s and MNE’s in an overall perspective.

Table 2. Main differences between SME’s and MNE’s[7]

Feature	SME’s	MNE’s
(1) Financial Resources	Low	High
(2) Use of advanced Manufacturing	Low	High
(3) Research and Development	Low	High
(4) Human Resources Engagement	Multiple domains	Specific domains
(5) Knowledge and Experience	Focused in a specific area	Spread around different areas
(6) Important activities	Outsourced	Internal
(7) Alliances with Universities	Low	High
(8) Organization culture	Low	High

As stated above, SME’s due to their small size, face a tremendous limitation due to their lack of resources, both physical and financial [7]. Nevertheless, exceptions rise in specific areas such aerospace and defense.

Regarding **financial sector(1)**, one of most vital sectors in these companies, a significant disparity lays between the two types of companies. For starters, SME’s that want to obtain finance must face expensive process handlings. In other words, the cost of applying for a lone are nothing but immoderate. Legal fees, administrative costs and costs related regarding information related to the acquisition are fixed, regardless of the amount to be loaned. Further costs must be applied in the presence of outside financiers. All these points together with lack of information and proper financial facilities in developing countries leads to a more severe problem.

The low amount of financial resources leads to a chain of consequences, which can be described as a snowball effect for the SME’s. In terms of **advanced manufacturing (2)**, the usage is considered low, since the investment in advanced manufacturing technologies is difficult to support. This lack of usage leads to incapability to invest in **research and development(3)**. This deeply affects the human resources sector. Instead, the **engagement of human resources (4)** is in multiple domains, “For example, the employees at SME’s are more likely to be ‘Jack of all Trades’ and less likely to develop high levels of expertise.”[7]. This leads to the fact that operators in SME’s do

not manage to gain a proper **specialization in a specific area(5)**, since the responsibilities inherited can range to multiple areas. This type of example does not present in MNE's due to their rich mass of employees. In these types of enterprises, the chances of an employee specialization in a certain area are higher due to sole focus performing related tasks.[7]

The consequences of this methodology can easily be applied to production. A low skillset, and engagement lead to the **outsourcing of production (6)** to control costs and time. Due to inability to attain a proper specialization, SME's no longer sustain a proper platform to attract universities and institutes. Consequent to this lack of self-updating policy to maintain up-to-date and cutting-edge methodologies leads to SME's not being able to generate **alliances with universities and institutes (7)**.

With the financial, human resources and production sectors affected by this snowball link, the structure of the company is going to "feel" the consequences. With the outsourcing of production and low skill of collaborators, the **company culture(8)** become poor with low capability to dynamize.[7]

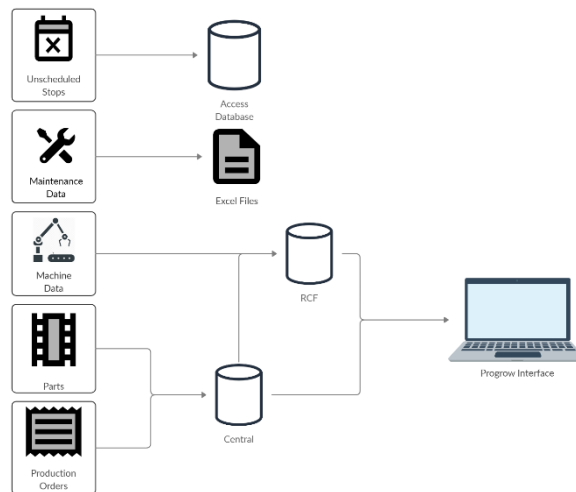
These can be stated as the most relevant aspects in a theoretical stand point. Nevertheless, they do not differ from the main studies performed in conducted to SME's. According to the digital business readiness study, "Many enterprises are lacking financial and often human resource too, to promote digital change internally"[5]. This leads a low level of completely digitally up-to-date enterprises of 27%. The main reason behind this low percentage can be explained with the fact that "SME's are lacking confidence in information security and data protection. Without this confidence, the transformation of business and manufacturing processes threatens to stall."[11].

4 Case Study at a Portuguese Company

A Portuguese company with a production lines with heterogeneity of equipment, showed in **Error! Reference source not found.** From initial analysis and the interview conducted in this company it was inferred that the four machines generate in a total of nine types of log files. Each of these Log files is generated under different circumstances and with different time-spans. In other words, since these are automatically generated and updated in each machine, they must be extracted within a week from its creation to safeguard the data generated. The first data extraction contained data regarding the previous week of operations. To allow the creation of a continuous dataset for analysis, it was established to perform weekly extractions, preferentially at the beginning of the week (Mondays), to streamline the process of communication and data transfer in the project. This methodology could not produce more substantial advantages regarding the SPI machine, since it does not allow for data extraction while machine is in operations. The unscheduled stops in the production lines are registered in loco by the operators, which are then processed and stored in a custom Database (DB), Access Database. Regarding maintenance plans, executions and reports, these are registered in Excel files without being processed and stored in a data-

base. The Central DB can be considered as the bridge between sales, production and logistic departments holding data regarding their daily basis of operations.

Fig. 1.Data flow of HFA production



Since the files maintained the same structure, any content deviation generated a trigger in the script. Consequently, it led to the entire row of data being sent to quarantine, therefore safeguarding the output file and the database for possible corruption due to unexpected data insertion. The quarantine file would be analysed at the end of the script executions to understand what data was generated incorrectly by the machine.

The process of data integration resembled Extract Transform Load (ETL) methodologies. The reason behind this statement relies on the fact that this methodology allows the system to perform a second analysis of the data regarding its content. In other words, by analysing the data in the output files before inserting in the database it is possible to understand incorrect data type insertion and therefore prevent possible errors. Therefore, quarantine tables were added in the database to hold incorrect values or rows from the files. Once the data is inserted correctly in the database, the last step is to assess the quarantine tables and understand why the rows were redirected.

Once data is stored properly, and a time-frame is generated with enough delta for analysis, the following step is to breakdown the features by understanding which can provide a better result in terms of algorithm predictions. In this step, two datasets are analysed, from the two pick and place machines. The analysis conducted to the files allowed to achieve linkage between the ERR_LOG and LOT_LOG, through the time-stamps. This relation further enhanced the dataset by understanding what type of board was being produced in each error registered.

From the original 54 features obtained through the linkage of the two datasets of P&P1 and 2, modifications were executed to discard features that did not uphold vital weight into the prediction stage.. Features such as temperature, vibration and engine

metrics were not available, since the types of equipment do not contain sensors to attain such information and engine metrics are not registered.

The second step regards the discard of irrelevant features. The features shown in **Error! Reference source not found.** were discarded from both machine's data since they did not register information that could be used for prediction. Also, the feature OPERATOR_CALL_TIME was discarded only in the dataset of P&P2 since it only contains NA values. Further 18 features were discarded in both datasets because they regarded the split of START_DATE_TIME, SETUP_DATE_TIME and FINISH_DATE_TIME. The reason behind this action is due to the fact these features can uphold a viable weight in the Data Visualization stage. With this operation, the number of features available changed from 54 into 27 in P&P1 and 26 in P&P2. From the execution of the algorithms, it was possible to extract the results available in Table which shows the three best datasets and their results in each algorithm for the two P&P machines. Full results are available in annexe N (P&P1) and annexe O (P&P2).

Table 3 - Algorithm's results for P&P1 and 2

Machine	Features	Algorithm	Accuracy (%)
Pick and Place 1	D1TRANSFER_CT_MAX TRANSFER_CT_MIN STANDBY_CT_AVE	NB	20.67
		SVM	44.13
		Adaboost	43.02
	D4PICK_UP_ERROR PARTS_VISION_ERROR MARK_VISION_ERROR	NB	13.41
		SVM	44.69
		Adaboost	46.93
	D7OPERATOR_CALL_TIME MARKREC_CT_MAX MARKREC_CT_AVE	NB	07.82
		SVM	49.72
		Adaboost	50.84
Pick and Place 2	D1WORKING_RATIO MOUNT_RATE MOUNTED_BLOCKS	NB	20.00
		SVM	44.65
		Adaboost	44.65
	D5TRANSFER_CT_MAX TRANSFER_CT_MIN STANDBY_CT_AVE	NB	26.98
		SVM	40.97
		Adaboost	43.72
	D10RECOVERY_TIME NO_PARTS_ERROR MOUNT_CT_MAX	NB	35.81
		SVM	41.86
		Adaboost	41.86

Results fluctuate regarding each dataset and model as expected since no sub-dataset is the same. From the initial analysis, it is possible to see that the model with the lowest results overall was NB (lowest result of 8% accuracy and highest of 36%). Regarding the SVM and Adaboost, the results obtained are similar. More specifically, for the datasets D1 and D10 in P&P2 the two models obtained the same accuracy. Nevertheless, it is possible to see that the best result was obtained through the usage of Adaboost in P&P1 (51% accuracy in D7) and P&P2 (44% accuracy in D1), since also in D5 (P&P2) it obtained a higher accuracy (45%) once compared to SVM. Regarding the overall results, it is possible to see three features that match both pick and place machines (D5 and D1) obtaining average results compared to the remaining ones.

5 Conclusions

From the analysis conducted throughout this paper regarding Industry 4.0 and main features of SME's and MNE's it is possible to understand the main reasons that support the lack of investment in new technologies. Latest achievements regarding methodologies and practices require a solid foundation and finance, to provide a sustainable growth for SME's which justifies the holdback from SME's.

Due to their lack of positioning in current markets, which are more and more competitive, these companies desire fast solutions to their problems, therefore maintaining methodologies that MNE's tested and approved throughout the years. Due to their capability to shape-shift into their desired solution, these companies must face the output of the market in a short-term basis, therefore invalidating the main basis of thought regarding industry 4.0. This line of thought regards a long-term vision where hefty finance is a fixed variable in the equation of going a step towards new income. SME's behave in a solid perspective where they "Don't take a step bigger than their leg". Nonetheless, this strategy to maintain position may provide negative consequences, more considerably inadequate health in a long-term statement, due to their lack of capability to self-innovate and achieve new competitive advantages. Therefore, this confirms the simple line of survival, where the runt of the litter dies.

For SME's to enter this revolution without compromising their structure they must understand the possible implementations that allow to achieve the best results with a low initial investment. This step is vital to stop the snowball effect described in this paper. **One possible solution is the creation of a new framework.** In other words, by providing a "step-by-step" approach, vital information can be attained in a simplified way allowing SME's to understand prior to implementation phase which elements of Industry 4.0 can be implemented and how.

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