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Level of Automation in the Small and Medium-sized Enterprises and its Impact (Case Study)

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Abstract: The production of mass with better quality and low price, requires more sophisticated automated systems of production, these equipment's become ubiquitous in all companies. The Moroccan companies attach great importance to the automation systems, they were equipped with the latest range of equipment to meet the requirements of the market. The level of automation in the Moroccan companies is in progress, it has not reached to an adequate level. In this study, we are going to present a survey of automation in the Moroccan companies in the three main industrial sectors (textile, agri-food and the automobile). In addition, we will discuss the skills required for the people in charge of its equipment as well as their impacts based on a case study.

Key words: Automation, level of automation, production system, impact, equipment, Fez

INTRODUCTION

The increase of productivity and the quality improved of products at low prices are the concerns of all companies. This requirement, strongly linked to the request of the customers, encourages them to invest massively in the new technologies in particular in the automated systems of production. Despite the high cost of these systems, companies continue to acquire these facilities which they have played a decisive role in the modernization of enterprises and in their quest for economic competitiveness.

Thanks to technological progress, production systems become more sophisticated, fast and multi-tasking. In terms of effectiveness, the automated systems are very powerful because they can work continuously for hours and hours. This power and precision of production systems make companies attract more.

The number of production systems has not stopped from progressing in companies during this last decade which presents a major challenge for the agents and their skills to adapt with the current trend. Yet, the number of such equipment does not reflect a true picture of the level of automation, since, the exact definition of the level of automation in the enterprises has not yet had the unanimity.

The Moroccan companies also give much importance to the automated systems, they were equipped with the latest range of equipment such as the programmable logic controllers PLC, the numerical control machines and the local industrial networks, despite this investment the Moroccan companies have not yet reached a satisfying level of automation.

MATERIALS AND METHODS

Level of automation in companies

Definition of automation: The evolution of the production systems has experienced a large scale during the last century. The mechanization has replaced the handicraft work during the industrial revolution which extended from the end of the 18th century and particularly the 19th century, it was characterized by the considerable development in terms of the techniques and methods of production of material goods. This revolution allowed the large-scale production of various products. The market demand in manufactured goods were very high because all what were product at that time were not enough for the consumers. With the evolution of technologies, the automated systems became ubiquitous in businesses and met the requirements of the market.

Despite the reputation of the automation in all areas such as aviation, automotive, smart home, medicine and industry in companies during these last years, this concept has not been able to have a single definition, several researches construct the meaning.

The online dictionary Larousse defined the automation such as the total or partial cancellation of

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human intervention in the execution of various tasks, industrial, agricultural, domestic, administrative or scientists. In addition, automation is the fact to assign impossible tasks to be done by human beings to the machines (Cederfeldt and Elgh, 2005) which means open or closed loop (Parasuraman *et al*., 2000). It is regarded as the substitution of the physical labor and mental health of the human being by the machine (Sjobakk *et al*., 2014; Vagia *et al*., 2016; Frohm *et al*., 2008).

The automation system, according to Staroswiecki (Bakkari *et al*., 2015) has a goal, control the changes made by the physical process. This control is carried out by the aid of sensors and actuators at the level. The concept adopted by Verlinde (Bakkari *et al*., 2015) for the automated systems which are based on the following functions of the system which are: lead, maintain, monitor, secure. However, Bayart (Bakkari *et al*., 2015) does not take into account the operators in his model. In this approach, the automation system is considered as an interface between the physical process and operators. For Cauffriez (Bakkari *et al*., 2015), the automated system takes the principles of a physical system either the internal or the external.

Despite these definitions which characterize the automated systems, another definition adapted to the industrial context is that of Chiron (Bakkari *et al*., 2015) who divides automation in two parts, the first part is the control section and the second one is the operative part. The control section contains the logic operation of the process that it wants to automate, it sends orders to the operative part which executes with the help of actuators and which it returns information from the sensors. The control section also manages the dialog with the operator most of the time through supervision. Yet, the automation is designed to be compatible with human capabilities (Kaber and Endsley, 2004).

The interest of the companies to equip by automated systems is to have the speed and the precision during the execution of the tasks to have a better quality of the product, to minimize the cost of products and of the labor force and to have an efficient reserach (Hodgson, 1963).

The automation does not exist in a mode all or nothing (Kaber and Endsley, 2004; Parasuraman *et al*., 2000) but there is a consistency between the two modes: manual and automatic. And this characterizes the degree of automation in the enterprises which it depends essentially on the industrial sector, the size of the company and the ability to invest in new technologies.

Level of automation: The fact to go from manual reserach to the use of the tools has been regarded as a kind of automation (Frohm *et al*., 2008). The automation systems have been developed with the emergence of the electronic and the use of computers in the manufacturing companies.

The levels of automation have been presented by several works, each work defines a number of levels of the automation (Vagia *et al*., 2016; Frohm *et al*., 2006; Sjobakk *et al*., 2014; Endsley and Kiris, 1995; Endsley, 1999; Sheridan, 2011). They are classified between three and twelve levels of automation at the beginning by the manual work up to the full automation or the autonomy of the system. Yet, the levels of the decision to automation (Parasuraman *et al*., 2000) are classified on a scale of 10, that is to say that in the lowest level the machines have the necessary data for the operators and the take no decision. In contrast, the top-level machines ignore the human being. They decide and act all alone without the intervention of the human.

In the study of Frohm *et al*. (2008) the level of automation is subdivided according to the tasks performed in two parts: the mechanization and computerization. All tasks performed either cognitively or physically and they were considered, respectively as computerization and mechanization.

Despite this abundant research and taxonomy of levels of automation, the exact definition of this concept remains variable. Previous researches have proposed different definitions. But there is no fixed definition which adapt to consistent levels of automation. There are some proposed definitions processed for the level of automation.

Different definitions of the level of automation: Frohm *et al*. (2008) the extent to which human energy and control over the production process are replaced by machines. The level of automation incorporates the issue of feedback as well as relative sharing of functions in ten stages. Degree of mechanization is defined as the technical level in five different dimensions or work functions. The level of automation goes from direct manual control to largely autonomous operation where the human role is minimal. The level of automation in the context of expert systems is most applicable to cognitive tasks such as ability to respond to and make decisions based on, system information. The level of automation is defined as the sharing between the human and machines with different degrees of human involvement. Level of automation is a continuum from manual to fully automatic operations. The level of automation can be defined as an amount of the manning level with focus around the machines (Cederfeldt and Elgh, 2005) which can be either manually operated, semi-automated or fully automated.

Frohm *et al*. (2006) the relation between human and technology in terms of task and function allocation which can be expressed as an index between 1 (total manual work) and 9 (total automation) of physical as cognitive tasks.

Sjobakk *et al*. (2014) the level of automation may be defined as the degree to which automation can be used in a production process to replace human labor by machines. Kaber and Endsley (2004) level of automation refers to the level of task planning and performance interaction maintained between a human operator and computer in controlling a complex system. Marquez and Ramirez, (2014) levels of automation indicate the degree to which the human operator or the automation has control or authorization over specific tasks. Endsley (1997) levels of automation can increase or decrease situation awareness depending on the involvement of operators

After all these years of the attempt to find an exact definition based on consolidate research an exhaustive definition concerning the level of automation is not yet established. All of these definitions are true of course but the list could grow again and again, especially if one wants to define the level of automation in the enterprise because all these definitions deal only with the level of system.

Automation in enterprises: Thanks to the technological progress, most of the companies are equipped with automated systems. These later have taken on the role of the operators which was done manually by these operators in a few hour, these automated systems are often done in a few minutes or less and with precision.

In terms of efficiency, the production automated systems are very powerful because they can work without stopping for hours and hours. This power and precision of production systems make companies fascinated them and continue to invest in them despite their costs which remain very high. This fascination of automation has been regarded as a kind of betrayal by the operators (Bakkari *et al*., 2015), they thought that the automated systems took their places.

In any companies, the operators work in harmony with the systems but the difference is mainly at the number of the operators. These later believe that this relationship is inversely proportional, that is to say if the number of automated systems increased, the number of operators are decreased and vice versa. In contrast, the automated systems require very qualified agents, experienced supervisors and the regular maintenance. Therefore, the increase of systems requires the increase of personal (Beach, 1967). The automation in the enterprise is a double-edged sword as it may present benefits to operators, it can also hurt (Onnasch *et al*., 2014) but the benefits are more remarkable than the injury.

The studies which have been processed in the level of automation in the company are very rare but few studies which have tried to determine the degree of automation through defining the automated company as a company with at least one of these following equipment: wired logic, digital control, programmable controller and micro-computer (Franck and Gaussens, 1992). In this study, we have adopted the same concept to measure the level of automation in the enterprises and its impact.

Case study: The Moroccan economy is characterized by a wide diversification and a great openness to the national and international market. In our study, we are interested in the textile, agri-food and the automobile sector in order to measure the level of automation in the SMEs and the control of agents of these automated systems.

The textile sector represents a strategic sector within national industrial activity by its contribution to the aggregates of the sector (27% of jobs and 7% of the value added industrial). The agri-food represents one of the industrial sectors of Moroccan economy. It is the first industrial sector of the country which benefit from a high national and international demand. Today, there are 29% of industrial enterprises, employing more than 90,000 persons. There is an obvious growth in a term of the Moroccan automobile sector over the past 10 years. Its performance is particularly noteworthy in the export (first sector exporter) and the creation of jobs.

The elaboration of the questionnaire: In this study, we rely on a quantity based approach in the form of questionnaires which allowed us to gather valuable data in order to determine the level of adoption of automated systems by small and medium sized enterprises. The questionnaire is divided into two complementary parts. The degree of automation in the SMEs: to know the number of automated systems in the SMEs used by sectors (we will not focus on other types of automated systems). The demanding capabilities to use the automated systems by operators: the knowledge among the employees who are regularly using automated systems.

After we have defined the aspects to be dealt with in this study, we started by the development of the questionnaire under the Sphinx Plus2 V5 software which is dedicated to the collection, processing and analysis of data (Fig. 1).

The choice of the sample: The industrial fabric of Morocco is made up of the majority of SMEs, the study is based on a sample of 12% of the SMEs in the three industrial cities. The sector the most dominant in the city of Fez is the textile, Casablanca is known as an industrial crossroad we have chosen there the agri-food sector and

Fig. 1: Automation: a section of the questionnaire

the Tangier free zone abounds of companies operating in the automobile sector. The collection of data has been gathered by the on-site visit of the SMEs and also sending of the e-Mails.

RESULTS AND DISCUSSION

Number of automated systems: In the textile sector the study reveals that the rate of the industrial equipment by automated systems, is weak in small and medium-sized enterprises. For nearly 45% of SMEs operating in the textile sector have <10 automated systems, the SMEs who have between 10 and 20 systems do not exceed 34% in contrast those that exceed 20 equipments are almost 21%.

Furthermore, approximately 15% of SMEs within the agri-food community have <10 automated systems, 36% of industrial enterprises have between 10 and 20 systems of production, for more than 20 equipment the rate of SMEs agri-food is 49%. Concerning the automobile sector, 67% of companies which have more than 20 automated systems in contrast 9% of these later have less than 10 equipment and 24% have between 10 and 20 automation systems.

The difference in these percentages between the three industrial sectors is mainly due to the requirements of customers, the delicacy of the tasks performed and the nature of the market envisaged (local market or export), for example, the customers of the automobile sector demand pieces which respect the standards of safety and precision to the extent of micrometer.

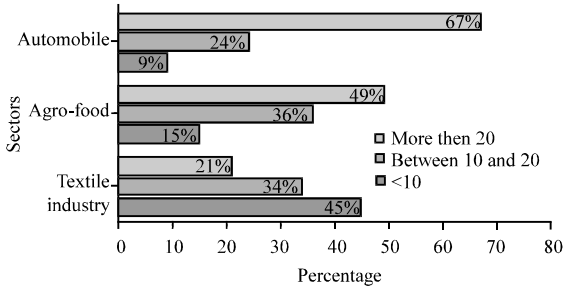

Fig. 2: Rates of automated systems in SMEs in the 3 sectors

The majority of SMEs enterprises which are surveyed, almost 96%, stated that they have implemented automated systems on the first day of the creation of the company. In contrast 4% of SMEs, from the automotive sector, pursued its investments in the development of their chains of production after the establishment and this happened either by the addition of new automated systems or during a launch of a new product or after the expansion (Fig. 2).

Use of automated systems: Figure 3 shows that the users of automated systems in the companies are predominantly the operators which they are classified in the first row with 74%. Almost 21% of the technicians are accustomed to working with these equipment's. A part of the engineers estimated by 5% manipulates the production systems, this rate is judged by their responsibilities of the chain of production or by the launch of a new product or well to do the maintenance.

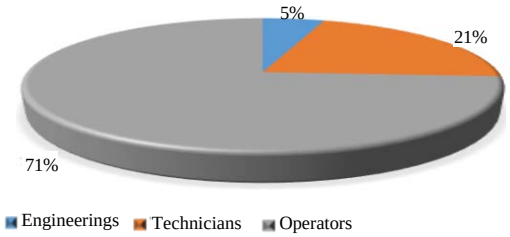

Fig. 3: Use of automated systems

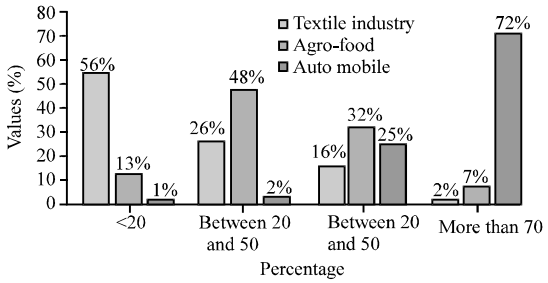

Fig. 4: Distribution of skills required by sector to use automated systems

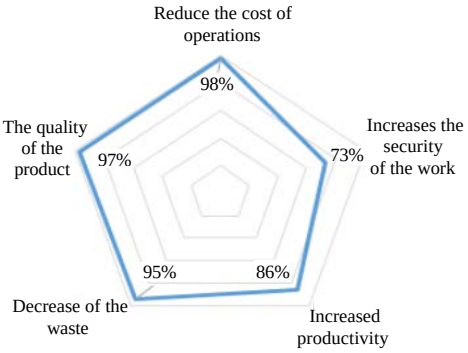

Fig. 5: Global impact of automated systems in the three sectors

Despite the habit of use of automation systems by the operators, they do not know the basic interventions of the equipment. During a power failure or a new reconfiguration, operators can remain blocked and await the intervention of their hierarchical superiors.

If the companies were engaged in the organization of continuing training courses in favor of their agents, they will be able to remedy this problem.

Required skills for the use of automated systems: In fact, the three industrial sectors admit that the skills required for the use of automated systems of production differ from one sector to another. The automobile sector says that 72% of their employees have more than 70% of the skills necessary to the use of automated systems, 25% of the users of these systems have between 50 and 70% of the skills and the 3% which remains divided in 2% who have skills between 20 and 50% and finally, 1% of them have less than 20% of the skills.

Regarding to the agri-food, the rate of employees who have more than 70% of the skills is a little weak at only 7%, those who have skills between 20 and 50% of the use are estimated by 48% of people. The percentage of those who have skills between 50 and 70% is about 32% and those who have <20% of the skills are 13%.

The textile sector is characterized by a weak percentage, only 2% of skills are required by more than 70% of their employees and only 16% of users of automation who have between 50 and 70% of the skills, those who have skills between 20 and 50% are estimated by 26% and more than half of these users, 56% of people, have <20% of the skills.

According to the data above, it can be seen that the companies of the automobile sector require the profiles in which their curriculum is adapted with the needs of the companies (53% of cases). In addition, they spend more time to train their employees (61%) on the automated systems.

Concerning the textile sector, the curriculum of 18% people hired adapt to the needs of the companies in this sector in contrast 9% of its employees benefit from continuous training. For the agri-food sector, companies recruit persons which their curriculum adapt to their needs (29%) in addition they fit in organize ongoing training for their employees (30%) (Fig. 4).

The impact of automated systems : Any other investment provided by the companies in the textile, agri-food and automobile sectors in favor of their employees generally aims to:

- Increase productivity (86%)
- Reduce the cost of operations (98%)
- Reduce the waste (95%)
- Increase the security of the work (73%) and
- Have a better quality of the product (97%)

Figure 5 represents the overall impact of automated systems in the three industrial sectors. The majority of companies are seeking to reduce the production processes, i.e., invest in the new automated systems to minimize the costs of operations at keeping a better quality of the product in the same time and the reduction to the minimum waste. In addition, the safety of employees remains among the concerns of small and medium sized Moroccan companies and it plays a vital role in the increase of the productivity.

CONCLUSION

For many researchers, the question of the level of automation in the enterprises remains a problem the exhaustive definition is not yet made. In this study, we have tried to collect most of the definitions cited in the scientific literature in order to approach the readers to a clear definition of this concept. Then, we have presented a study carried out in the three Moroccan Cities and in the three sectors: textile, automobile and agri-food. Concerning the equipment of these companies by the automated systems as well the persons responsible for their uses. In addition, we have presented the degree of skills of these agents with the manipulation of these systems. The study has shown that the level of automation in the small and medium sized Moroccan companies is in permanent progress, new technologies are already installed in the companies but that is not the desired degree in comparison with the developed countries. In addition, regular users of these automated equipment are predominantly the operators, the continuous training of its staff allows the improvement of their yields and efficiencies, yet this is rarely to find the companies which are involved in the continuing training.

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