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Management**

**Industry 4.0 adoption challenges in Jordanian
pharmaceutical manufacturing**

Theses for doctoral thesis (PhD)

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(Introduction) thesis motivation, study model main questions and hypotheses

Choosing the topic of Industry 4.0 was popular among many researchers in the last 10 years. This fact opened my eyes to what this digitalized machinery are capable of in terms of manufacturing as well as other applications in many other aspects of life. However, relating it my knowledge of Disaster management and occupational health and safety, the fact of at what extent machines can replace men power in the workplace made me astonished. After a deep look onto the Jordanian manufacturing era, Jordanian unemployment rate, and the available data online by the government and the studies on the academic level, I found that, **first**, Jordan has many issues and challenges in adopting IoT. **Second**, unemployment rate in Jordan is around 50% in the youth (knowing that only high skilled human force can operate and manage Industry 4.0). By those two findings I was motivated to choose this topic in Jordanian pharma manufacturing.

Why Pharma Industry? Because, even though it is the most advanced in terms of technologies in Jordan, there is no real adoption of Industry 4.0, once that the Jordanian human power is not ready to meet the skills and competencies required by Industry 4.0. and here was the gap. **This thesis aims to** fill this gap by recommending what decision makers

in the government and in the manufacturing top management must do to. Jordan lacks a clear roadmap, in which some of the necessary elements for the implementation of Industry 4.0 are considered: elements like energy, raw materials and qualified human power. In Jordan, we can see the availability of fundamentals of renewable energy, in a century where insufficient energy is a crisis worldwide. Also, Jordan has quite a rich environment of raw materials and minerals related to manufacture chipsets for the robotics of Industry 4.0 emerging technologies.

The thesis aims to suggest what are the top related skills and competencies, raise the awareness to adopt these technologies among the related decision makers.

Studying the pharma industry can encourage other industries in Jordan to adopt these emerging technologies. EU funds for innovation gave Jordan the chance to adopt these technologies by creating an I4.0 excellency center in Amman. This project is aimed to help the top management in the manufacturing era in Jordan to adopt I4.0. On this matter, the thesis attempts to see what this project is about and how really it is contributing adopting Industry 4.0 in Jordan, by using bibliometric analysis to seize the most important and top related documents about all the topic areas of Industry 4.0 technologies, skills, competencies, the pharma 4.0 concept in the world, and Jordan economy. Later, a reviewing all the statistical reports from the Jordan government takes place. Third, the interviewing of EU funded project managers of Industry 4.0 in Jordan, reflecting the knowledge gained from studies made by me in relation to the topic areas prior the

thesis work. After the accumulative findings, the thesis heads to explore the pharmaceutical manufacturing in Jordan using quantitative study on the top management of pharmaceutical industry.

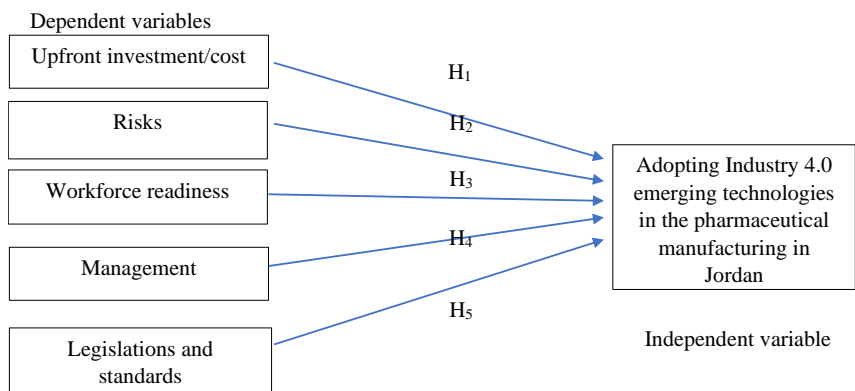
Main research questions and hypothesis

In developed countries, adopting Industry 4.0 is the most recent technology in mass production since 2011. Now, developing countries started to have grants and funds to adopt those new, emerging technologies of the smart factory and automated manufacturing of Cyber physical systems in connection with the IoT. This is usually done using qualitative and quantitative studies. In quantitative studies, survey is used relying on many different adoption models of innovative technologies, two in special. The most popular was the *Technology Acceptance Model* (Davis, 1989); the second is part of the system engineering process life cycle, which consists of two approaches, document based, and model based *Model-Based Systems Engineering* (MBSE)(Suri et al., 2017). A mixed model of both will be used to examine only the challenges in adoption to Industry 4.0 emerging technologies in pharmaceutical manufacturing in Jordan. The study variables can be found as the drivers to adopt Industry 4.0 or any technological development process, but rather examining the challenges only is an objective to reach for the aim to highlight the barriers or challenges. Using the modified model of both TAM and MBSE, it was found that this adoption can be quite difficult due to many

factors.

Adopting smart factory technologies is the dependent variable, which was examined using a 5 Likert scale; the study model is adopted from both MBSE model-based system engineering and TAM model of accepting new technologies. In this model, the independent variable is the adoption of Industry 4.0 emerging technologies. Different from other studies, we consider ten technologies rather than fourteen, and the blockchain technologies are also included, due to its importance to Pharma Industry.. The concept of Operator 4.0 is also important to relate, as much as their skills and competencies.

Below, the main technologies of the independent variable can be found; the challenges would represent the dependent variables of the thesis.



Study hypothesis

H₁ Industry 4.0 upfront investment/cost has a negative effect on adopting the I4.0 in the Jordanian pharmaceutical manufacturing.

H₂ Adopting Industry 4.0 in the Jordanian pharmaceutical manufacturing is more likely to increase the risks and leave a negative impact on adopting this technology.

H₃ Workforce readiness to meet the operator 4.0 requirements will decrease the ability of adopting Industry 4.0 in the pharmaceutical manufacturing in Jordan.

H₄ Pharmaceutical manufacturing management decisions have a negative impact on adopting Industry 4.0 emerging technologies in the manufacturing in Jordan.

H₅ Legislations and standards in Jordan have a negative effect on adopting Industry 4.0 in the pharmaceutical manufacturing industry in Jordan.

Thesis Methodology

This thesis used a set of different methodologies to reach the primary and secondary data which have been used by me to conclude the study results. This methodology uses the computer to search for the most related data which can be found in the methodology part of the study. Both quantitative and qualitative methods of reaching to the main results were used, which you can

find in more details in the thesis. An important thing in this thesis is the use of the human knowledge, combined to the computer abilities of AI. In the last part of the thesis, we visit the topic of how AI applications can write and relate the facts in the structured algorithms.

Conclusion

Industry 4.0, or even more advanced manufacturing activities, are always signs of newer times that bring many opportunities and challenges at the same time. What makes the difference between an opportunity and a challenge is the way that they are handled. In the first place there are drivers that steer the wheel of this technology's integration. This integration technology wheel is the key driver of the world order. In each period, the world order changed due to wars, natural or man-made disasters. These changes are the pushing force of that wheel. The results of the world order change can be seen in the geopolitical maps of the world. The aftermath of these drivers and world order changes over history have accumulated advanced knowledge and disasters to handle and learn from. Climate change, overpopulation and food security are those top debated issues or man-made disasters. Those challenges of our world must be faced so we can assure the safe existence of humankind on the Earth. Before the First Industrial Revolution, humankind started the pursuit of more land to have more resources.

More resources means more land for agricultural purposes. For sure, gold and silver were fever at all periods in human history, but it is absolutely useless in times of hunger, and they alone can't provide food security. At the dawn of the first Industrial Revolution, another natural source was there to start another race between nations. Steam engine was not the first thermal energy option which, historically, had implications on human life through the years, it was believed that even the Egypt Hyksos had a form of thermal energy application. But at the time of steam engine the transportation became easier than ever. Steam engines made oil one of the resources that nations started to scout for; their interests were not only in lumber. Then new perspectives towards economic relations and exchanges, and the old commercial trade routes came to bring change in what people knew possibilities of maintaining commercial transactions and distance between social groups. As mentioned in the literature, these changes escalated to take us to the time of merging knowledge. Thus, the world order has changed over time with these inventions. Now in 2022 we have reached a new technological advancement. This knowledge is what some call the digitalized world order.

The power of new communication methods using the internet technologies and satellite internet connection is called the 5th generation of telecommunication. In here, we can realize that

human beings must adjust to these new advanced technologies. Here, it was necessary to seize all the related documents that could be found online using the scientific web-based search engines, like *Scopus database*. Questionnaires were analyzed and this resulted in a view of necessities to implement the Industry 4.0, also taking into consideration the context of COVID-19. Also, that study was used to see what the level of awareness regarding these technologies among High-Tec organizations employees is, to have a result of two important points in that topic: that people have difficulties assimilating what Industry 4.0 is, even though that some understanding about it and its technologies can be noticed. This means that the training programs of the high tec companies which mainly provide outsourcing services to other organizations actually lack “*higher-quality*” training programs and a high qualified work force in regards of Industry 4.0 skills and competencies. Here, the study could confirm what are the best skills and competencies model that need to be adopted in the training of work force. Also by conducting another research, as a conference, that aimed to highlight the use I4.0 technologies in disasters management by using CC and Big data to create a distance learning to mitigate covid-19 crisis not only in Jordan but the in whole world . This research was done to see how the schoolteachers without training could use CC and Bigdata in the distance learning with school students. The challenge was not only facing schoolteachers but also

the students and their families in Jordan during COVID-19. Yes, indeed this could be the solution of overcrowded schools but at the same time it could affect the interpersonal and personal skills of the students which can leave an impressive aftermath on the primary school students in terms of mental health and physical inactivity, which are health risk factors on adults and children. We could see in this research that the use of computer is challenging many families in Jordan who are affected by the economic impacts that arose in the last decade in Jordan and other countries, after the economic crisis of 2008.

Talking about the new advanced technologies can't be done without the use of AI and computer research techniques. This study used many open AI software to reach for all the information's which was included in secondary data part of this research and related to the research main topics. Involving the computer advanced search and using these methods led the study to the acknowledge that AI became a powerful and advanced technology in terms of the Machine learning algorithms. ML algorithms can be classified into three major groups: supervised, unsupervised and reinforcement learning.

Using ML algorithms and connect it on the cloud to analyze and classify the information in the work place then transfer these data to imagery can be displayed using AR can achieve the aim operator 4.0 which is human workforce aided by the computer for flowless

manufacturing and maintenance experience (Fantini et al., 2020; Kaasinen et al., 2020; Longo et al., 2017; Roldán et al., 2019; Romero et al., 2016, 2017; Ruppert et al., 2018; Scheffer et al., 2021; Segura et al., 2020). If we combin the abilities of I4.0 and operator 4.0 it can be the only way that the humans can surpass the machine. but still the question would be in two scenarios. The first one would be what if the machine surpassed the human in terms of capabilities to perform tasks?

And the second scenario could be what if the system crashed and the operator 4.0 can't perform tasks in the basic needs processing? regarding this the study had to investigate those questions by asking the people who have more experience in these felids in Jordan and in Hungary which was done in the challenges of skills and competencies in Industry 4.0 part of the study as well in the interview with the project managers of I4.0JO . Also, this research project had the chance to explore the opinion of an expert in nano semiconductors manufacturing and quantum physics specialist. And all of them were asked the same question which was the following: what are the skills and competencies that human workforce needs the most to cope the labor market requirements? And the second question in this regards was what are the set or sets of skills and competencies that humans needs to operate in I4.0 environment and in the same time if the system went off because of unfortunate event like a disaster or energy issues.

And to make this question more clear for the interview, they have been told to choose between the most important skills set that fits the two scenarios. Those sets were the same in the skills and competencies part of the study. First of all they told me to go further into Construction, pharma, food and beverages, and automobile industry because those are the most industries that use advanced technologies and they have the biggest share of GDP not only in Jordan but in the world as well. Then they added that they believe based on their personal experience of using these systems in manufacturing that humans can't produce even a single nano semiconductor processor without using robots, but still the creation of these robots must go through human operators and the maintenance of these robots is done by humans. Also humans can understand customer disasters better than any computer or AI. Which is related to the analytical skills and interpersonal skills as most of them agreed on that the most two important skills sets were the following which fit the two scenarios at the same time Adopting I4.0 and disaster mitigation:

- Social/Interpersonal (intercultural skills, language skills, communication skills, networking skills, teamwork, ability to transfer knowledge, leadership skills),
- Methodological (creativity, research skills, problem-solving, conflict solving, decision making).

And if the system goes down, they believe that most human operators can't perform tasks in manufacturing. When I have asked the people who manage the industry 4.0 project in Jordan about what skills are a must in both cases of system down or in the case of AI and CPS aided manufacturing, they have mentioned that the analytical skills are the most important in terms of adopting challenges and the interpersonal skills can always be the solution to have a better decision-making process.

In here we could see how important the personal and interpersonal skills are for humans to be in the center of this industry. However, these skills are impacted by the technological and digitalized world order we raise our children in. this topic is one of the recommended topics that this study is suggesting that it needs further studies. Another main issue is the continuous production of pharmaceutical products, which is necessary worldwide. From this point and recollecting previous studies, it is clear that further researches on pharmaceutical manufacturing should be done.

In Germany, United States, and China, we can see the overcoming of the challenges of adopting Industry 4.0 in the manufacturing, not only into smart factories but rather smart cities. Smart cities are meant to be more headed to solve the crises of overpopulation, climate change and food security. But in Jordan the case is way too different in terms of technology and even sustainability. Without the use of Industry 4.0 emerging technologies, the unemployment

rate is 50% in the youth, while in Germany population is declining. In these terms, the two countries can't be compared, but we can see what challenges were met in developed countries in the process of implementation of Industry 4.0 and consider them as driver to adopt. This step was taken by the EU funded projects for innovation to help Jordan in adopting Industry 4.0.

In this matter this thesis took a turn to have a new scientific result in regard to these technologies adoption in Jordan, based on the recommendation of previous studies, and expert's recommendation. Adopting Industry 4.0 in the pharmaceutical manufacturing in Jordan considered as the most advanced sector of the Jordanian economy in technology, it was found that there are 155 companies producing pharma products for humans and animals. Only 14 of 155 companies are included in the pharma manufacturing association that gathered the top advanced companies that complies with the Pharma Regulatory Affairs of MEANA area, EU and FDA. This association was studied using a questionnaire as data collection instrument, and only the challenges were discussed during the conduction of this research, because previous studies have been done proving that there is no real implementation of Industry 4.0 in Jordan manufacturing. All the alternative hypotheses of the study were accepted which confirm the theories of the project about the challenges. Many things were revealed in this project which are considered new in

the academic studies. Also, this study is considered as KPI key performance indicator and this is considered as novelty. Human workforce in Jordan lacks skills and competencies, while the skilled work force has been migrating to the gulf countries since the beginning of 1900's, which leaves Jordan with many challenges to improve the economy even more so to start the process of adopting Industry 4.0 applications. The internet infrastructure and the energy issue, extent to the fact of geopolitical effects, are the biggest challenging parts of adopting real manufacturing practices. Adopting atomic energy and even the overpopulation caused by the war around Jordan is threatening the whole country in terms of water security.

New findings of the dissertation

- The study found that the higher citation of a document is not related to the core science of the document, and, after an investigation of why is that, it turns out to be the name of the author and the institution they represent is the reason behind too many citations. And this was one of the reasons to exclude some documents from the research which could be found on both Scopus and web of science. Also, an element which is not a new scientific result but is worth of mentioning is that using google scholar to search for academy and peer reviewed sources is less likely to be useful because of the algorithm google is using which leads

to the most connected content to the search keywords. other databases like MDPI excluded because any open access related to the topic can be found on Scopus database

- It is true that there are no real Industry 4.0 technologies adopted in Jordan, even though that there is some publishing attesting that, but the reason became known after reviewing the project managers experience and interviewing the authors online. One point the project manger of I4.0Jo mentioned that the institutions are saying that they implemented I4.0 but they didn't implement it and this because they want to be eligible for the project funds.
- Universities in Jordan need more than buying new training software to teach the students about these core technologies of Industry 4.0 They need subscriptions to the necessary tools which, in some cases, are more expensive than the cost of the hardware.
- The real reason of challenges to adopt these technologies in Jordan is the lack of standards in the government to regulate these technologies, especially TRC, and to have permission to buy related IoT technologies, most of which are not regulated, as we can see from the opinion of the mangers and from reading the white papers of IoT published by TRC.

- The Jordanian labor market lacks skilled human power who can meet the requirements of Operator 4.0, due to the frequent migration of qualified workers to the gulf countries and Germany as mentioned in the open-end question of the skills and competencies survey. Which could be confirmed by contacting many Jordanian employees using LinkedIn platform as well.
- Studies have found that the set of skills existent in the labor force to be able to use the technologies of Industry 4.0, but none of them actually support the scenario of a system down, and we need a certain set of skills to operate the old systems as a contingency plan. Therefore, this dissertation has found and suggested that interpersonal skills and analytical skills are the most important to be developed in case of a system down crisis. According to the study questionnaire and the interviews done with the industry 4.0 project managers.
- Also, this thesis could confirm that the use of Industry 4.0 technologies was pushed by the covid 19 crisis by using these technologies as respond plan to this crisis which could solve too many issues in the world and one of them is the crowded school classes that could be turned online. Now those constancy plans became part of our daily life.

- At last, by using the questionnaire to explore the top management of pharma manufacturers in Jordan, we can see that the replies to the statements confirm that there is a huge cost associated with adopting such projects, and the feasibility of this kind of studies; that can reflect how much the challenges overcome the drivers when considering the matter of adopting this industry.

Thesis recommendations and the relevance of the thesis

1- Recommending the need for senior management in Jordanian pharmaceutical companies to support the initiatives of Adopting industry 4.0 emerging technologies, due to their importance in promoting smart manufacturing and improving the level of manufacturing performance in these companies.

2- Working on training and developing workers in Jordanian pharmaceutical companies to deal with Industry 4.0 by offering various courses and seminars.

3- Recommend the need to pay attention to the use of smart manufacturing strategies to enhance manufacturing performance using emerging technology provided by industry 4.0.

4- It is important to create an organizational culture and organizational climate supportive of Industry 4.0 by changing the organizational philosophy and values that enhance the use of Industry 4.0 by these companies.

5- It is important to change legislation and regulatory standards to accommodate the dynamic changes in the markets, which improves the adoption of Industry 4.0.

6- Invite researchers to conduct future studies focusing on the effects of industry 4.0 technologies such as big data analytics and the Internet of Things on performance in these companies. Also, the further studies to use IoT in terms of flashing floods predictions and dams' management is a must to contribute in the solutions of water insecurity in Jordan.

Bibliography

- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319–340.
- Fantini, P., Pinzone, M., & Taisch, M. (2020). Placing the operator at the centre of Industry 4.0 design: Modelling and assessing human activities within cyber-physical systems. *Computers and Industrial Engineering*, 139. <https://doi.org/10.1016/j.cie.2018.01.025>
- Kaasinen, E., Schmalfuß, F., Öztürk, C., Aromaa, S., Boubekur, M., Heilala, J., Heikkilä, P., Kuula, T., Liinasuo, M., Mach, S., Mehta, R., Petäjä, E., & Walter, T. (2020). Empowering and engaging industrial workers with Operator 4.0 solutions. *Computers and Industrial Engineering*, 139. <https://doi.org/10.1016/j.cie.2019.01.052>
- Longo, F., Nicoletti, L., & Padovano, A. (2017). Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. *Computers and Industrial Engineering*, 113, 144–159. <https://doi.org/10.1016/j.cie.2017.09.016>
- Roldán, J. J., Crespo, E., Martín-Barrio, A., Peña-Tapia, E., & Barrientos, A. (2019). A training system for Industry 4.0 operators in complex assemblies based on virtual reality and process mining. *Robotics and Computer-Integrated Manufacturing*, 59(May), 305–

316. <https://doi.org/10.1016/j.rcim.2019.05.004>
- Romero, D., Bernus, P., Noran, O., Stahre, J., & Fast-Berglund, Å. (2016). The operator 4.0: human cyber-physical systems & adaptive automation towards human-automation symbiosis work systems. *IFIP International Conference on Advances in Production Management Systems*, 677–686.
- Romero, D., Wuest, T., Stahre, J., & Gorecky, D. (2017). Social factory architecture: Social networking services and production scenarios through the social internet of things, services and people for the social operator 4.0. *IFIP Advances in Information and Communication Technology*, 513, 265–273. https://doi.org/10.1007/978-3-319-66923-6_31
- Ruppert, T., Jaskó, S., Holczinger, T., & Abonyi, J. (2018). Enabling technologies for operator 4.0: A survey. *Applied Sciences (Switzerland)*, 8(9), 1–19. <https://doi.org/10.3390/app8091650>
- Scheffer, S., Martinetti, A., Damgrave, R., Thiede, S., & van Dongen, L. (2021). How to make augmented reality a tool for railway maintenance operations: Operator 4.0 perspective. *Applied Sciences (Switzerland)*, 11(6). <https://doi.org/10.3390/app11062656>
- Segura, Á., Diez, H. v., Barandiaran, I., Arbelaz, A., Álvarez, H., Simões, B., Posada, J., García-Alonso, A., & Ugarte, R. (2020). Visual computing technologies to support the Operator 4.0. *Computers and Industrial Engineering*, 139. <https://doi.org/10.1016/j.cie.2018.11.060>
- Suri, K., Cuccuru, A., Cadavid, J., Gerard, S., Gaaloul, W., & Tata, S. (2017). Model-based Development of Modular Complex Systems for Accomplishing System Integration for Industry 4.0. *MODELSWARD*, 487–495.

Related publication

- Alhloul Abdelkarim /Industry 4.0 as a challenge for the skills and competencies of the labor force: a bibliometric review and a survey Sci (2413-4155): 4 3 Paper 34. 17 p. (2022) journal article

- Abdelkarim Alhloul 4.0 workforce preparedness a step ahead in the unforeseen conference article
- Alhloul Abdelkarim Challenges of the Schoolteachers and Student's Families in Jordan During the Covid-19 / INNOVATIVE SOLUTIONS International Scientific Conference 5 November 2020, Sopron – Conference Proceedings
- Kiss É (Kiss Edit Éva Társadalomföldrajz) CSFK/FTI/Department of Human Geography ; Alhloul A (ALHLOUL ABDELKARIM business administration philosophy of management) SOE/FE/Széchenyi István Gazdálkodás- és Szervezéstudományi Doktori Iskola Az Ipar 4.0 várható foglalkoztatási és térszerkezeti kihatásai a magyar ipar példáján In: Kiss E (Kiss Endre Filozófiatörténet) Chapter in Book
- Alhloul Abdelkarim (ALHLOUL ABDELKARIM business administration philosophy of management) Patnaik, S. (ed.): New Paradigm of Industry 4.0: Internet of Things, big Data & Cyber Physical Systems HUNGARIAN GEOGRAPHICAL BULLETIN (2009-) (2064-5031 2064-5147): 69 2 pp 209-212 (2020) Book Review