

# Evaluating the Industry 4.0 Readiness of Manufacturing Companies: A Case Study in Kuwait

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## Abstract

The project discusses a case study on evaluating Industry 4.0 (I4.0) readiness in manufacturing companies in Kuwait. To assess the I4.0 readiness of the firms, the IMPULS I4.0 readiness survey was distributed to manufacturing companies. The purpose of the survey is to determine the readiness level and the progress of companies on their journey towards I4.0. Survey results were then analyzed and showed that the readiness in the Data-Driven Services dimension was around 60% and is considered the highest percentage in the analysis. On the other hand, the Employees dimension had the lowest readiness percentage of 23%. The results illustrated that Kuwaiti manufacturing companies need the most improvements in the Employees dimension. Based on the survey results, the ABC Company was selected as a case study for I4.0 digital twin implementation. Two simulation models were created for the production line of blue plastic drums in the company, one for the current line and another for after the implementation of I4.0. The results indicated that the throughput of the ABC Company will improve 228% with the I4.0 implementation and the investment will be recovered in 4 years.

## Keywords

Industry 4.0, Readiness, IMPULS survey, Manufacturing

## 1. Introduction

Industry4.0 (I4.0) is the current trend of data exchange and automation in manufacturing technologies. It includes cyber-physical systems (CPS), the internet of things (IoT), augmented reality, cognitive computing, and several other technologies. The new world industry is driven by data and the internet connected by devices that are capable of processing ever-growing amounts of information. The fourth industrial revolution is moving to create more flexible, efficient, and productive manufacturing. There are many benefits of I4.0 such as the ability to produce huge amounts of products, clarifications to eliminate errors and waste, high-speed manufacturing, high-quality products, and software defects prevention. Industry 4.0 can provide manufacturers with many benefits such as improved efficiency, lower costs, higher revenues, and increased innovation.

I4.0 has nine technological pillars which are: internet of things (IoT), cybersecurity, additive manufacturing (3D printing), simulation, autonomous robots, augmented reality cloud computing, horizontal and vertical system integration, and big data. The corporations have to advance in these dimensions for a successful I4.0 deployment. In this context, the term readiness refers to the state of being familiar with the I4.0 concept but not being capable to implement it, and its purpose is to know the starting point and allow the development process. On the other hand, maturity is the state of being complete, perfect or, ready, but may involve some progress in I4.0 system development. The role of maturity models is usually a tool for understanding and measuring the maturity of an organization or process for certain target situations. The difference between readiness and maturity is that the assessment of readiness occurs before the maturation process. With regards to Industry 4.0 IMPULS, Empowered and Implementation Strategy, Digital Operations Self-Assessment, and The Connected Enterprise are some models for assessment of readiness or maturity.

In the past few years, several studies have been conducted to measure the maturity and readiness level in Industry 4.0 on manufacturing companies from countries all over the world. So far, we couldn't find any study that shows the maturity level of Kuwait's manufacturing and mechanical companies, which is resulting in the uncertainty of Kuwait's current state and level of I4.0 implementation.

There are several objectives of this work:

- Have a clear and understanding background about I4.0's readiness models.
- Collecting data about the readiness and maturity of the manufacturing companies in Kuwait to adopt the idea of industry 4.0.
- Understand the impact of successful I4.0 deployment.
- Recognize the benefits of the concept of I4.0 in engineering and business fields.
- Prepare action items depending on the readiness outcomes.
- Help companies overcome the limitations and constraints they are facing in implementing I4.0.
- Create simulation models before and after the effect of I4.0 implementation.

The rest of the paper is structured as follows. The next part reviews I4.0 readiness and maturity models and their dimensions. The third part discusses the methodology including the survey and the simulation models. The fourth part documents the survey findings and simulation results. Finally, conclusions are given in the last section.

## 2. Background and literature review

### 2.1 Industrial revolutions:

Industrial production needs to adapt rapidly to the ever-changing market requirements. Industry 4.0 is a present and a promising future for business integration and manufacturing. The development of industrial manufacturing systems can be presented as a path through the four revolutions (Figure 1), where this path evolves from manual work towards Industry 4.0 concept. First, in the 1800s the first industrial revolution (Industry 1.0) began with mechanical power and mechanization. It has moved the industry from manual work to the first manufacturing processes. Then, the second industrial revolution (Industry 2.0) has enabled manufacturing and mass production, because it was triggered by electrification. It combines the introduction of mass production without the allocation of products. After that, the third industrial revolution (Industry 3.0) occurs through the introduction of microelectronics and this is called digitization. In this manufacturing, production lines are flexible, and a variety of products are manufactured using programmable machines, but their flexibility is linked to the quantity of production. We are now in the fourth industrial revolution (Industry 4.0) which has been developing of Information and Communications Technologies (ICT). It has decentralized control and advanced communication (IoT) through a technological basis of smart automation of cyber-physical systems. The reorganization of classical hierarchical automation systems into a self-organized cyber material production system is the result of this new technology of industrial production systems. Moreover, that allows the flexibility of both of mass custom production and production quantity (Rojko, 2017).

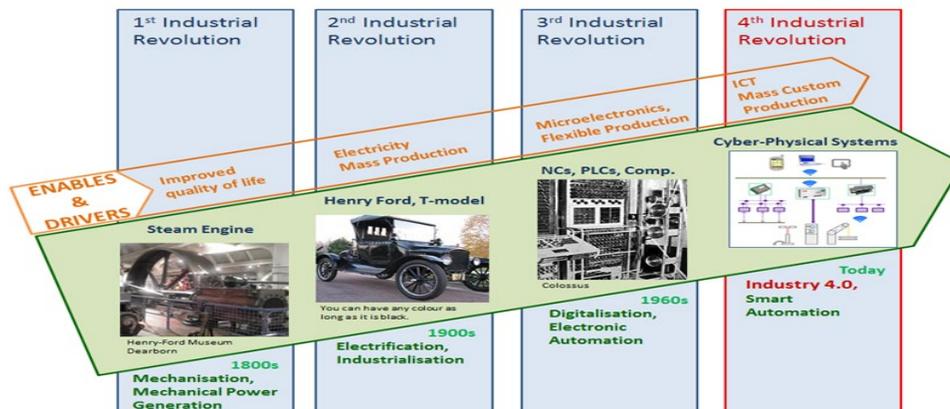


Figure 1. The four industrial revolutions (Source: Rojko, 2017)

### 2.2 Industry 4.0:

The dynamic business world has an increased demand for transforming the products in order to compete with highly advanced economies. Hence, it has automated the demand for highly advanced and digitalized goods for the progress of an economy. This whole scenario leads the economies to move towards the new revolution called industry 4.0. This revolutionary transition represents the fourth generation in the manufacturing world, the more advanced and digitalized business world. Hence this movement from the first generation towards the fourth generation leads the economies to adopt the use of computers and automated the whole manufacturing process; it

consequently enhances the smart data for industries. Since the concept of industrialization has evolved, the technological paradigms have substantially shifted the progress in mechanization, electrical synergy, and the extensive use of digitalization (Brandherm and Kröner, 2011, p.376). Nowadays I4.0 is used to define the vast range of present concepts about the use of smart factory. In such situations manufacturing in the factories is completely automated and is equipped with sensors and autonomous systems. Lasi et al. (2014) said that this concept of I4.0 was firstly introduced by a German government, whereas later on it was widely known for future high-technology-based strategy. With the increasing trend of I4.0, the technology providers need to foster the industries to face the challenges and overcome them by embracing the opportunities. So I4.0 is the new trend of robots arises who work with the workers in the factories. Meanwhile, autonomous pieces of machinery and vehicles are modifying and facilitating the production line workers. Moreover, sensor networks are used to connect the designers to the workers of the factory, which replenishes the machines and software, and hence the suppliers are directly connected to the customers (Stock and Seliger, 2016).

### **2.3 IMPULS-Industry 4.0 Readiness**

Lichtblau et al. (2015) stated that the readiness model, IMPULS, depends on the following six dimensions of I4.0 (Table 1). Each dimension involved a different set of questions that were collected from the survey to measure the readiness of the companies. The first dimension is strategy and organization. I4.0 is beyond developing current processes and products using advanced digital technologies. It attempts to provide a chance to grow by developing a new business model, it has a great implementation of strategic importance (Lichtblau, et al., 2015).

The second dimension is Smart Factory. A highly automated smart workpiece will control and monitor the production process, systems that organize themselves and guide without the interference of humans because it provides sensors and integrated for greater transparency and planning capabilities, information that is being delivered and resources are used more efficiently by involving digital modeling to smart storage, gathering and processing data. The smart factory depends on cyber-physical systems (CPS) which link the physical and virtual worlds by transferring through an IT infrastructure that is called the Internet of Things (Lichtblau, et al., 2015).

The third dimension is Smart Products. Its characteristics are to think for itself, production efficiency, collects data, monitor and optimize the status of the product from communicating with the customers and manufacturers because of the physical products that it provides the ICT components (sensors, communications interface, RFID, etc.) (Lichtblau, et al., 2015).

The fourth dimension is Smart Operations one of the important I4.0 pillars. It is recognized as the self-controlling workpiece it checks if the processes and products are completed smartly, and it's known in synchronization of production planning systems and supply chain systems (Lichtblau, et al., 2015).

The fifth dimension is Data-driven services. The main objectives in this area are to arrange the future business models and to increase customers' benefits. It will rely on evaluation, analysis of the collected data, and enterprise-wired integration. It can receive, send process information for operational processes, and have physical and digital components because of the equipped physical IT (Lichtblau, et al., 2015).

The sixth dimension is the Employees; the working environment is important. It requires the workers to have new skills and also qualifications companies have to prepare their employees by training and education (Lichtblau, et al., 2015).

Table 1: I4.0 IMPULS Dimensions (Source: Lichtblau et al., 2015)

Dimensions	Associated fields
Strategy and organization	<ul style="list-style-type: none"> <li>* Implementation status of Industry 4.0 strategy</li> <li>* Operationalization and review of strategy through a system of indicators</li> <li>* Investment activity relating to Industry 4.0</li> <li>* Use of technology innovation management</li> </ul>
Smart factory	<ul style="list-style-type: none"> <li>* Digital modeling</li> <li>* Equipment infrastructure</li> <li>* Data usage</li> <li>* IT systems</li> </ul>
Smart products	<ul style="list-style-type: none"> <li>* Data analytics in usage phase ICT add-on functionalities</li> </ul>
Smart operations	<ul style="list-style-type: none"> <li>* Cloud usage</li> <li>* IT security</li> <li>* Autonomous processes</li> </ul>
Data-driven services	<ul style="list-style-type: none"> <li>* Availability of data-driven services</li> <li>* Share of data used</li> <li>* Share of revenues derived from data-driven services</li> </ul>
Employees	<ul style="list-style-type: none"> <li>* Skill acquisition</li> <li>* Employee skill sets</li> </ul>

Based on the six levels of the readiness assessment, companies can be grouped into three types of groups, which makes it more professional, easier to draw conclusions, check progress, condition, summarizing results relating to I4.0 (Lichtblau, et al., 2015). The three levels are provided in Figure 2 below:

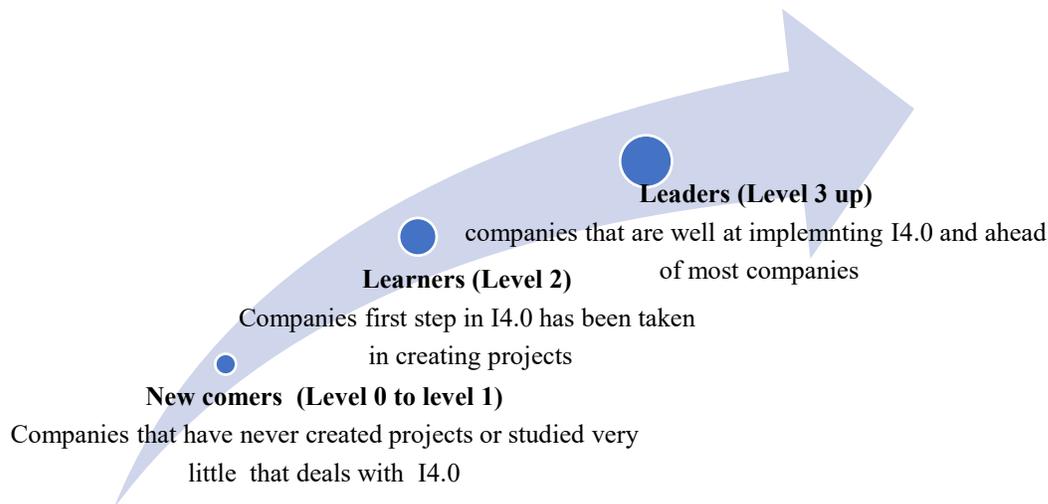


Figure 2. IMPULS six levels readiness

A comparison of the four maturity and readiness models is shown in Table 2 below. There is only one model that represents readiness which is the IMPULS model and the rest of the models represent Maturity which are Digital Operation Self-Assessment, The Connected Enterprise, and Industry 4.0 Maturity, (Akdil et al., 2018).

Table 2. Comparison of Industry 4.0 maturity and readiness models

Maturity/readiness Model	Maturity/readiness dimensions	Industry Scope
IMPULS- Industries 4.0 Readiness (Lichtblau et al.,	It includes a 5-stages readiness model with 6 dimensions and 18 criteria. Each stage is defined clearly with its'	This model's main concern is the manufacturing, engineering industries. Has a limited application area.

2015)	hurdles and action plans.	It measures companies' readiness to implement and integrate the industry 4.0 concept.
Industry 4.0/Digital Operation Self-Assessment (Schumacher et al., 2016)	It includes a 4-staged maturity model with 7 dimensions and 6 steps. Criteria are undefined in this model. It provides short action plans and comments resulting in online assessment.	This model includes digitization of horizontal and vertical value chains, focusing on how to develop the company products and services aiming to have new business models to implement. Has wide application area.
The Connected Enterprise Maturity Model (Rong, 2014)	It includes a 5-staged maturity model with 5 dimensions. Maturity criteria are undefined in this model, and it lacks an assessment tool.	This model focuses on the information and operation technologies of companies. What happens if an organization has a lack of operations dimension and a limited application area?
Industry 4.0 Maturity Model (Schumacher et al., 2016)	It includes a 5-staged maturity model with 9 dimensions and 62 items. Maturity is examined under 5 levels. It uses a basic formula for calculating maturity level and assessment.	This model focuses on the manufacturing industry, comprehensive maturity model. Has a limited application area.

### 3. Methodology

In this part, we will be explaining our methodology and the steps we are going to use in detail. Our process design will be the steps in the survey research process, as well as the steps of the simulation, each explained clearly, and fully.

#### 3.1 Survey

The following will be the steps in the survey research process:

##### 1) *Define the problem*

In this case, the problem is to assess Kuwait's manufacturing companies' readiness level in implementing I4.0.

##### 2) *Develop research questions*

For this step, we did our researches on a specific model which is IMPULS – Industry 4.0 Readiness, that will help us evaluate and measure the level of readiness in the manufacturing companies chosen for the study.

##### 3) *Literature Review (acquire knowledge about research issues)*

In the literature review, we have gathered information and did several pieces of research on our main topic, which is I4.0 readiness, and its main four models. Explaining each model specifically and creating a comparison between them in the end, so we can choose the model that is mostly related to the manufacturing industry.

##### 4) *Defining and operationalizing concepts*

Readiness is the state of being familiar with the concept of I4.0 but not being capable to implement it. This state comes before engaging in the maturing process.

##### 5) *Deciding on a survey approach*

For our survey approach, we are going to meet with companies, face-to-face, as it is the best way to accomplish the survey, to avoid some questions being misunderstood, or getting poorly filled surveys.

##### 6) *Pretesting questionnaire (and revising as necessary)*

In this step, as a group, we all fully revised and understood the surveys chosen and made some necessary improvements. After that, we handed it to experts in the industrial field to look at it and make sure all the questions are clear and understandable before handing it out to companies.

##### 7) *Sampling*

For the sampling step, we are going to choose a population size of 157 companies that have total finance of one million Kuwaiti dinars or above, and employees of one hundred or more. For our sample-size we are going to calculate it using the following formula:

$$n = (t^2 p(p-1))/m \text{ (Equation 2; Sample size equation)}$$

$x = 157$  companies

$n =$  required sample size

$t =$  confidence level at 95% (standard value of 1.96)

$p =$  estimated prevalence of the variable of interest (0.05)

$m =$  margin of error at 5% (standard value of 0.05)

For calculating the sample size, we are going to use a confidence level of 95%, which means our  $t$  (standard value) will be equal to 1.96, and our margin of error will be 5%. For the estimated prevalence of the variable of interest, we chose 0.05, because we want our sample size to be as large as possible for the results to be more accurate.

Calculation:

$$n = \frac{(1.96)^2 (0.05)(0.05-1)}{0.05} \approx 19.208 \approx 20 \text{ companies.}$$

We calculated the sample size to be approximately 20 companies, this means that from 157 companies we need to reach almost 20 companies.

#### 8) *Collecting data*

For this step, we are going to hand out the surveys to companies and then collect the data. We will be interviewing the company's expert engineers who will understand the survey and fill it correctly.

#### 9) *Data coding and entry using Excel*

In the following step, we will be presenting the collected data in the excel software in a data sheet. Then we will be able to determine the scores of the companies chosen to choose one for our plan.

#### 10) *Plan*

After collecting the data and analyzing it well, we will check if we have a company that is ready, if we do, we will create either a roadmap or a simulation for this company or both together. If not, we will look for a company that is not ready and will provide awareness, create a roadmap, or create a simulation for the company with the choice of doing all three together.

##### a) *Awareness:*

If a company is not aware of the industry 4.0 concept, we will clearly explain it and make the company aware of all its' benefits and importance by presenting the topic to them and showing them what this concept is changing in the industrial world.

##### b) *Roadmap:*

The roadmap plan is a way to improve the company's maturity level or to make a company mature to implement I4.0. A roadmap is a strategic plan used to reach the desired goal by following major steps for that purpose.

##### c) *Simulation:*

The simulation will be used to simulate models and show companies the level of improvement they will face after implementing I4.0. It will show the company's revenues before and after the implementation and how it will be increasing in the following years.

#### 11) *Analyses*

In this step, we will analyze the results, check if they are effective for our study, and can be written and presented to the companies chosen.

#### 12) *Writing up results*

In this step, we will gather the results and write them up in a report to be able to present our study in a professional understandable way for the following step.

#### 13) *Presenting/disseminating results*

In this step, we will present the written results and explain in detail all the steps taken in this process. After that, we will discuss and get feedback from experts to carry on with the project and to see if it can be implemented and shared.

#### 14) *Replication/extension*

If needed, we will replicate our study and apply it to several more companies, to improve and spread awareness about I4.0 which is our main topic in this project.

### 3.2 Simulation

The following will be the steps in the simulation study:

1. Understand the system
2. Put a clear goal
3. Formulate the model representation
4. Collect the data from the chosen company
5. Translate into modeling software (ARENA)
6. Validate the model
7. Verify the model
8. Design experiments
9. Make runs
10. Analyze and document the results

## 4. RESULTS

### Survey Results

Table 3 below shows the results of the survey for each company. The table shows the score given in each dimension, the sum of all dimensions together, and the readiness level given to each company. Company names were switched to alphabets to keep their information confidential. ABC Company was selected for this case study which is why it is the only company shown with its' name. Each level is represented with a specific color shown in the color legend.

Table 3. The results of the survey for each company

Company Name	Strategy&Organization (25)	Smart Factory (14)	Smart Operations (10)	Smart Products (19)	Data Driven Services (14)	Employees (18)	Sum	Level
A	14.24	8.73	6.25	16.63	10.50	6.43	62.78	Level 3
B	13.05	5.63	2.41	16.63	10.50	6.44	54.66	Level 3
C	12.33	8.64	4.98	14.25	7.00	4.17	51.37	Level 2
D	8.64	6.16	4.79	9.50	7.00	0.96	37.04	Level 2
E	7.23	6.74	4.88	11.88	7.00	2.89	40.62	Level 2
F	8.86	2.82	3.77	0.00	14.00	3.84	33.28	Level 1
G	1.25	0.58	1.90	11.88	0.00	2.88	18.49	Level 0
H	10.90	5.34	1.15	7.13	10.50	4.48	39.49	Level 2
I	10.53	10.67	5.37	9.50	14.00	8.38	58.45	Level 3
J	10.79	6.41	5.18	14.25	7.00	4.48	48.12	Level 2
K	15.39	12.04	6.23	14.25	14.00	5.79	67.70	Level 3
L	8.16	5.25	4.04	0.00	10.50	6.44	34.39	Level 1
M	15.29	8.24	4.50	16.63	10.50	4.50	59.65	Level 3
N	9.99	6.84	5.36	14.25	3.50	2.56	42.50	Level 2
ABC Company	12.59	11.45	5.79	19.00	10.50	3.21	62.54	Level 3
O	12.59	8.16	0.00	0.00	0.00	0.00	20.75	Level 1
P	3.95	3.78	2.52	11.88	3.50	0.64	26.27	Level 1
Q	16.02	10.58	5.29	11.88	7.00	1.60	52.36	Level 3
R	11.50	14.09	2.65	14.25	10.50	6.44	59.43	Level 3
S	13.87	13.08	4.56	10.00	10.50	8.08	60.09	Level 3
Average	10.86	7.76	4.08	11.19	8.40	4.21		
Readiness Percentage	43%	55%	41%	59%	60%	23%		

As shown in Figure 3, the radar chart represents the averages of each dimension of the I4.0 IMPULS model. These averages are calculated using the data collected from the manufacturing companies in Kuwait. Data-Driven Services seems to be had the highest average of 60% and is being strictly applied in most manufacturing companies in Kuwait. Next we have Smart products, Smart Factory, Strategy & Organization, Smart Operations with averages of 59%, 55% 43%, and 41% respectively. The weakest and most poorly applied readiness dimension is in Employees with an average of 23%.

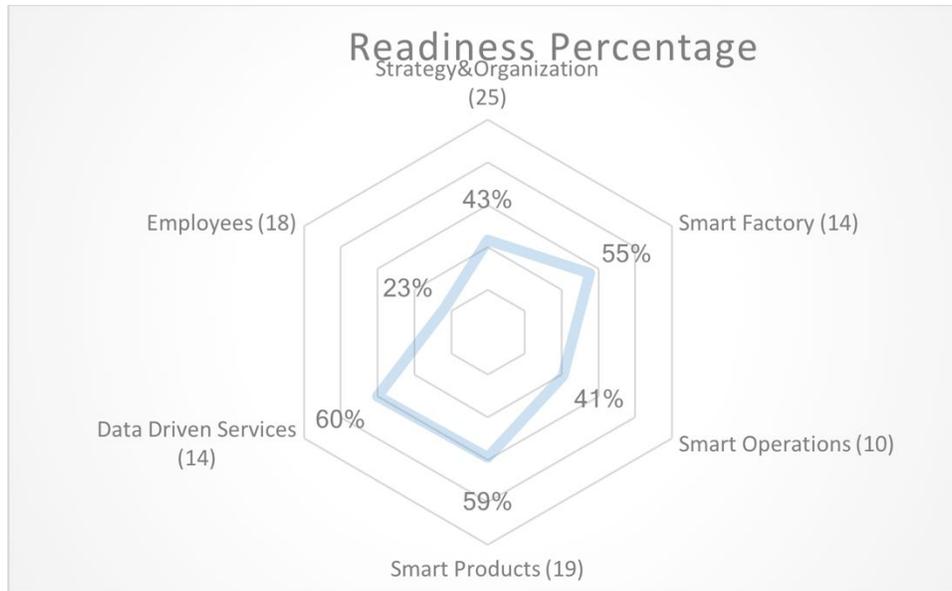


Figure 3. Readiness Percentage

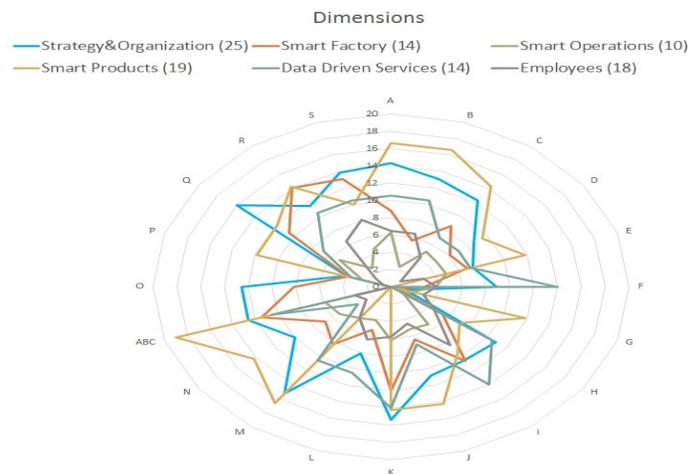


Figure 4. Dimensions

Figure 4 above, is another chart that shows the results of each dimension for each manufacturing company. This shows some companies have high scores such as K and ABC, which means they are ready and capable of implementing I4.0.

*Simulation Results*

Studying ABC Company performing before the usage of I4.0, and after implementing I4.0 in their production line. However, with collecting all the necessary data from the production area (number of machines, processing time, cycle time, defect rate, demand, raw material, the capacity of the machines, and number of products produced), two different simulation models will be created.

*Arena Model before implementing Industry 4.0*

The simulation will be applied for ABC Company that manufactures plastic drums with weight 9.8 kg that mainly focused on studying the process of manufacturing the plastic drums as shown in Figure 5 below.

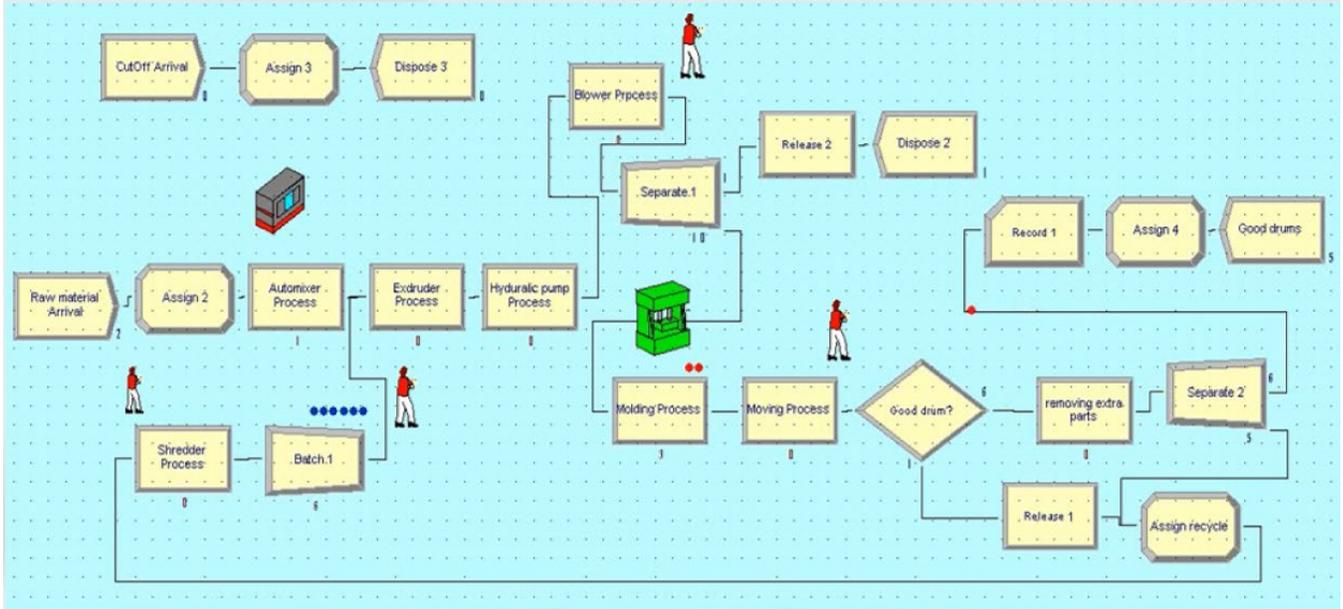


Figure 5. Arena model before implementing I4.0

*Arena Model after implementing Industry 4.0*

The process of manufacturing the plastic drums after implementing I4.0 is shown in Figure 6 below. It will follow the same steps but with slight changes in the machines and process excluding the Blower process, Molding process, and Shredder process and their machines. We will have with 3D printer process instead of the three aforementioned processes.

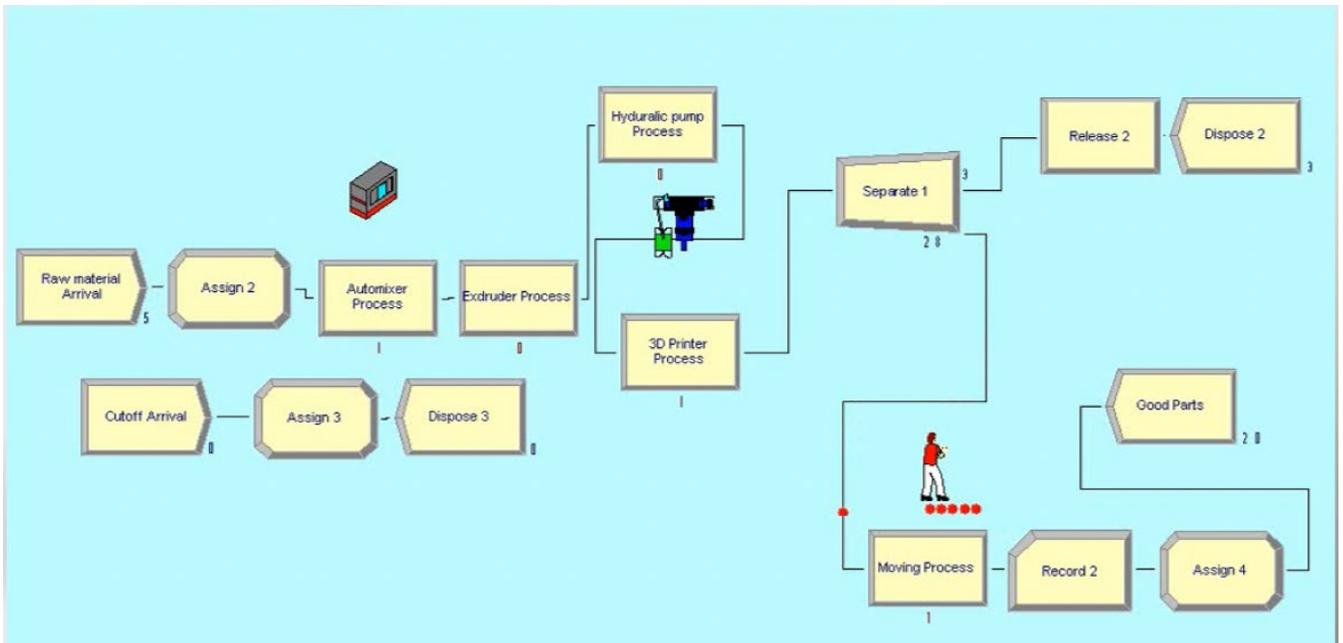


Figure 6. Arena model after implementing I4.0

The key performance indicators chosen are the total time and number of good drums. Table 4 below shows the simulation results from both models before and after the implementation of I4.0. Results show that the total time before the implementation of I4.0 is 286 mins, and the number of good drums is 148 drums. After the

implementation of I4.0, the total time is 321 mins, and the number of good drums is 545 drums. The last row in the table shows the number of drums per minute.

Table 4. Comparing Result Before & After Implement I4.0

	<b>Before Implementing I4.0</b>	<b>After Implementing I4.0</b>
Total Time	286 min	321min
Number of Good Drums	148	545
Drum per min	0.517	1.697

The graph shown in Figure 7 below shows a bar chart that compares drums per min, before and after the implementation of I4.0, which shows a 228% improvement.

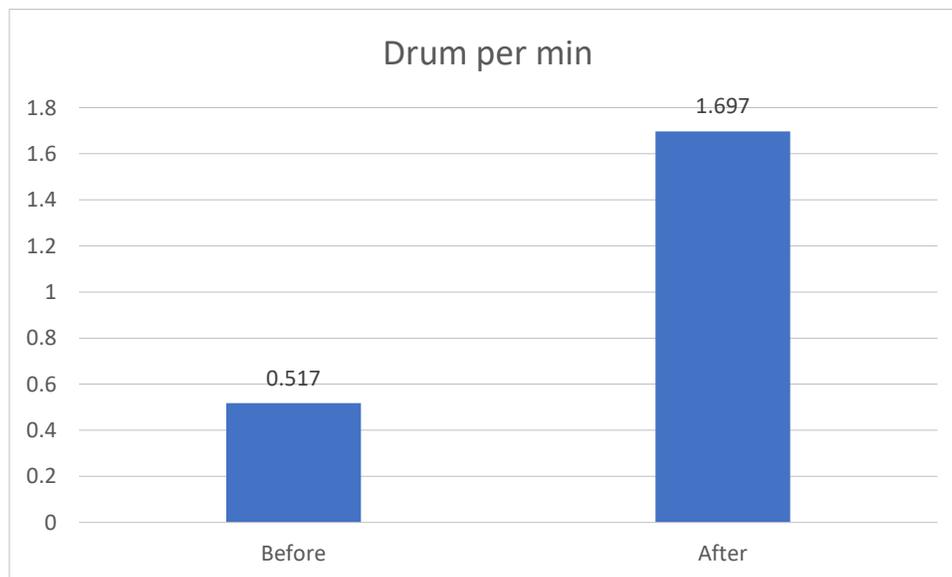


Figure 7. Compares drums per min before & After implement I4.0

## 5. CONCLUSION

In conclusion, I4.0 is a term that refers to the Fourth Industrial Revolution focuses on connectivity altering the way the industry responds to society through the smart interconnected pervasive environment. Through the journey for successful I4.0 deployment, understanding all the four readiness and maturity models with their dimensions and choosing the best model that is applicable for Kuwaiti manufacturing companies was accomplished. Completing qualitative research after gathering the surveys and analyzing the levels and the dimension for manufacturing companies, ABC company was chosen with the highest score. After collecting information on the products the company manufactures, we created experimental research to identify ABC Company production departments' complications and performance. In particular, two simulation models were built to simulate before and after the implementation of I4.0 relating to the manufacturing of drums (by using Arena Simulation software). The use of the 3D Printer for the production of the drums increased productivity by 228%.

## References

- Akdil, K. Y., Ustundag, A., and Cevikcan, E., Maturity and readiness model for industry 4.0 strategy, in *Industry 4.0: Managing the digital transformation*, pp. 61-94. Springer, Cham, 2018.
- Brandherm, B., and Kroner, A., Digital product memories and product life cycle, in *2011 Seventh International Conference on Intelligent Environments*, pp. 374-377, IEEE, 2011.
- Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., and Hoffmann, M., Industry 4.0, *Business & Information Systems Engineering*, vol. 6, no. 4, pp. 239-242, 2014.
- Lichtblau, K., Stich, V., Bertenrath, R., Blum, M., Bleider, M., Millack, A., Schmitt, K., Schmitz, E. and Schröter, M., IMPULS-industrie 4.0-readiness, *Impuls-Stiftung des VDMA, Aachen-Köln*, 2015.
- Rojko, A., Industry 4.0 Concept: Background and Overview, *International Journal of Interactive Mobile Technologies*, vol. 11, no. 5, pp. 79-80, 2017.
- Rong, H., *The-connected-enterprise-maturity model* (Doctoral dissertation), 2014.
- Stock, T., and Seliger, G. Opportunities of Sustainable Manufacturing in Industry 4.0, *Procedia CIRP*, vol. 40, pp. 536–541, 2016.
- Schumacher, A., Erol, S. and Sihni, W., A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises, *Procedia Cirp*, vol. 52, pp.161-166, 2016.

## Biographies

**Estabraq Mohammad** is an industrial engineering graduate. She received her B.S. degree in Industrial Engineering from the American University of the Middle East, Kuwait. She is fluent in both English and Arabic. She has great technical skills in several engineering software (Arena, Matlab, Minitab) as well as many soft skills including good communication, able to work under pressure, great team player, and is good with time management. Estabraq participated in two charitable volunteering programs; Ahli United Bank Kuwait's fun run for a good cause, to support environmental, health, and charity efforts. As well as, Arm of Aid's charitable art galleries where she showcased her art pieces where 50% of the profit went to charity.

**Lulwah AlBarakah** is a graduate with a B.S. degree in Industrial Engineering at the American University of the Middle East, Kuwait. During her study at the university, she gained technical skills, confidence to communicate effectively with audiences, time management, how to work smarter not harder by organizing and planning, etc. She continues gaining skills in Industrial Engineering to improve process and design, to optimize complex processes and systems, ergonomics and safety, manufacturing, and production via studying real-world problems.

**Sarah Kudair** Graduated with a bachelor of science degree in Industrial Engineering at the American University of the Middle East, Kuwait, during her study at university she gained skills, knowledge, confidence that she will implement her role successfully and gain valuable experience. She believes that the ways we make in life especially in difficult times shape the individual and therefore reflect on the communities. She challenged herself since last year "2020" of coronavirus pandemic by spending time while seeking employment; through securing membership of professional societies and joining courses such as Membership of Kuwait Society of Engineers, Membership of Institute of Society of Manufacturing Engineers "SME, Membership of Institute of Industrial & Systems Engineers "IISE", Project Management Professional Course, (PMP), Course on ICD Cyber Security Webinar, and Fundamental Advanced Course in Auto CAD.

**Abdullah S. Karaman** is an Associate Professor of Industrial Engineering at the American University of the Middle East, Kuwait. He received his B.S. degree in Mathematics from Koç University, Istanbul, Turkey; M.S. degree in Industrial Engineering from Bilkent University, Ankara, Turkey; and Ph.D. degree in Industrial and Systems Engineering from Rutgers University, New Jersey, USA. His research and teaching activities have been in the areas of business analytics, supply chain management, sustainability, multi-criteria decision-making, and simulation modeling. His research has been supported by the Department of Homeland Security, USA and Ankara Development Agency, Turkey. His works have been published in the European Journal of Operational Research, International Journal of Production Economics, Journal of Cleaner Production, Transport Policy, Sustainability Accounting, Management, and Policy Journal, and Journal of Air Transport Management, among others.