

**THE REPUBLIC OF TURKEY  
İSTANBUL KÜLTÜR UNIVERSITY  
INSTITUTE OF GRADUATE STUDIES**

**Case Study of the Impact of Using Artificial Intelligence with  
Cloud Computing in Smart Factory Management**

**MASTER OF SCIENCE THESIS**

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**Department: Industrial Engineering**

**Program: Engineering Management**

**Supervisor: Assist. Prof Dr. Ibrahim Ethem TARHAN**

**MAY 2022**

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## **LIST OF SYMBOLS**

|             |                             |
|-------------|-----------------------------|
| <b>AI</b>   | Artificial Intelligence     |
| <b>IaaS</b> | Infrastructure as a Service |
| <b>PaaS</b> | Platform-as-a-service       |
| <b>SaaS</b> | Software-as-a-service       |
| <b>FaaS</b> | Functions as a Service      |
| <b>SDC</b>  | The Scientific Data Cloud   |
| <b>OR</b>   | Operation Research          |

|                           |   |
|---------------------------|---|
| <b>Üniversite</b>         | <b>: İstanbul Kültür Üniversitesi</b>           |
| <b>Enstitü</b>            | <b>: Lisansüstü Eğitim Enstitüsü</b>            |
| <b>Anabilim Dalı</b>      | <b>: Endüstri Mühendisliği</b>                  |
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## **ÖZET**

### **AKILLI FABRİKA YÖNETİMİNDE BULUT BİLGİSAYARLA YAPAY ZEKA KULLANIMININ ETKİSİNE İLİŞKİN VAKA ÇALIŞMASI**

**Esraa AL DARABSEH**

Bulutun çalışması içinde yapay zekayı kullanarak, vaat edilen gelecek, kendi kendini yöneten bilgisayarlar yaratmaktır. Bulut ile kaynakları paylaşmak, firmalarda inovasyon seviyesini artırdı, çalışma ekibinin en düşük çalışma süresinde yüksek performanslı endüstriler geliştirmesine ve bir öncekinde erişilemeyen bilgi işlem gücü seviyesinde analiz etmesine izin verdi. Bu çalışma, bulut bilişim çalışmalarının, yapay zeka cihazlarını etkileyen ve bir iş büyümesine yol açan fabrika yönetimi üzerindeki etkisini araştırmayı amaçlamaktadır. Ek olarak, bu çalışmada, bulut tüketen bir şirket ile bir bulut tedarikçisi arasındaki bir SWOTL/PESTEL analizinden türetilen dış ve iç faktörleri incelemektedir. Ayrıca, tezde, firmanın toplam kârında altı ana ürünün en etkili gelirinin ne olduğunu kontrol etmek, gelirini maksimize etmek için bir model önerilmiş olup Lineer Regresyon kullanılmıştır. SWOTL/PESTEL analizinde ve ardından beyin fırtınası yöntemiyle toplanan ve üretilen fikirleri etkileyebilecek faktörler belirlenmiştir. Yedi değişkene dayalı olarak Lineer Regresyon yöntemi kullanılmıştır; altı ana gelir ve toplam kâr daha sonra aralarında bir ilişki kurmak için Minitab yazılımı uygulanmıştır. Etkileyici ürün, Solver yazılımı karı maksimize etmek için kullanılmıştır. Araştırma sonuçları, değişkenler arasında önemli bir ilişki ortaya koymuştur. Çalışmadaki ,sonuçlar, bulut hizmetlerinin kullanımının şirketin ekonomik büyümesi üzerinde olumlu bir etkisi olduğunu kanıtlamıştır.

**Anahtar Kelimeler:** Yapay zeka, Bulut, Akıllı Fabrika.

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**Program** : Engineering Management  
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## **ABSTRACT**

### **CASE STUDY OF THE IMPACT OF USING ARTIFICIAL INTELLIGENCE WITH CLOUD COMPUTING IN SMART FACTORY MANAGEMENT**

**Esraa AL DARABSEH**

By employing artificial intelligence within the work of the cloud, the promised future is to create self-lead computers. Sharing the resources increased the innovation, it allows to develop of industries with high performance in the lowest time of study and analyze it quickly. This study tries to investigate the effect of the cloud on factory management that affects artificial intelligence devices that leads to the development of business growth which in affect increase the profits. Also, this research examines the factors from SWOT/PESTEL analysis among a cloud provider and consumer. Besides, linear regression is used to measure the most influential revenue of the main products in the total profit of the firm and propose a model to maximize it. The factors determined that may affect SOWT/PESTEL analysis and by brainstorming the ideas gathered and generated. Linear regression was used based on seven variables; six main revenues and total profit then applied Minitab software to obtain a relation between them. The influencer product was used to maximize its profit by Solver software. The outcomes presented an important relationship between the variables under a framework. The study presented economic growth in the firm that used cloud with AI equipment and the results proved to increase the net profit after the framework was developed.

**Keywords:** Artificial Intelligence, cloud, Smart Factory.

# **1. INTRODUCTION**

## **1.1. Chapter Overview**

The first part provides an outline, description, and overview of the topic, which focuses on the use of artificial intelligence and cloud computing in engineering management and concentrates on the effect of using together in the smart factory to provide high-value products and strengthen the economy from the other side.

In section 1.2, a brief discussion that related to the research background is presented, 1.3 section presented a statement about the concerned area, or what requires to be improved, then sections 1.4 and 1.5 investigated the objectives of the study and the research significance. Followed by sections 1.6 and 1.7 showed the questions require to respond to the research and the research hypothesis, and the method presented in section 1.8, the last section 1.9, classified the structure of the research.

## **1.2. Research Background**

It has combined disruptive innovations in operations and processes production in digital manufacturing. Artificial intelligence introduces a vast database of machine learning functions in the industry. So, there is much information in the firms that requires management, it is hard to access from different locations, and the process of search function takes a too long time. They may store the same information in multi-time many copies, which leads to consuming the storage in a worthless way. The firms resorted to high demand for cloud computing in the industry in our era to obtain the benefits of this service with artificial intelligence technology, premier factories resorted to using and improving its capabilities by employing advanced technology to increase productivity and raise the global industry level.

The top factories aim to produce and manufacture high-value and novel industries with modern and advanced technologies in the world of industries. Global businesses gain a high wealth from adopting new technology in the factories. The

technology pillars can improve reliability and can help to increase the operations of commerce in the world and enhance the management of the firms with different locations of the branches. These lead to growing the economy rapidly. They inspire notable benefits, even the most products advanced by technology are far from ideal. They usually have issues or current challenges before they can deliver the advantages.

### **1.3. Research Problem**

This research tries to respond to the following questions that are in using artificial intelligence with the cloud within smart factories:

- Is the consumer company management affected by cloud computing?
- How does cloud computing affect artificial intelligence?
- Is there an economic impact on the company's growth?
- What are the strengths, weaknesses, opportunities, and threats related to the company's consumption of the cloud?

#### **1.4. Research Objectives**

This research aims to:

-To investigate the impact of using artificial intelligence with cloud in smart factory management.

-To discover the relations among smart firms that use cloud equipment based artificial intelligence, cloud computing provider, management of the factory, and its achievement.

-To estimate the relationship between the main quantitative variables in a medical smart factory: total revenue as a dependent variable versus the variables of vaccines, oncology, internal medicine, hospital, inflammation & immunology, and rare disease.

#### **1.5. Research Contribution**

-To find the impact of using the cloud for artificial intelligence machines on improving the management of the smart factories and affecting internal and external features of pharmaceutical companies.

-To improve research that discusses the use of the cloud in developing pharma products in pharmaceutical factories.

-To study the impact of using new pillars of information technology in the industry operation to exploit new opportunities, define the threats, and work to manage them to decrease its effect.

-To study how to determine if there is a major factor that the total profit based on in the company and work to increase its revenue within constraints.

## **1.6. Research Question**

This study aims to respond to the questions below:

### **1.6.1. Primary Question**

In the context of a medical smart factory, in particular, using artificial intelligence with cloud in the management:

-Does cloud computing impact artificial intelligence in the management of a medical smart factory?

### **1.6.2. Secondary Questions**

1-What are the unique competitive advantages of a medical smart factory using the cloud?

2-What are the possible issues of using the cloud from a cloud provider on the artificial intelligence machines in a medical smart factory?

3-Is there any relation between cloud and artificial intelligence in the economy of a medical smart factory?

4-Is there a specific part of the gross profit affecting the total company's revenue since using the cloud?

## **1.7. Hypotheses**

### **1.7.1. Main hypothesis**

H0: Using cloud-based AI machines have a possible positive effect on the management of a medical smart factory.

### **1.7.2. Secondary Hypotheses**

H1: Cloud usage builds new opportunities and strengthens its advantages in medical smart factories.

H2: Using the cloud creates issues and concerns for consumers.

H3: Cloud computing has an impact on developing the growth of a medical smart factory.

## **1.8. Research Method**

This thesis produces a quantitative and qualitative analysis of a specific medical smart factory. The principal of the research is an in-depth study of relevant factors with PESTEL analysis sides. The primary objectives of the study are to evaluate a company's competitive position in a specific medical smart factory business and analyze the potential of this sector provided the firm strengths and the cloud opportunities in the context of competitive and comparative advantages. Start brainstorming with strengths and weaknesses as internal factors, review the internal analysis of this factory, and listed it. Then the thought about the opportunities that advanced from cloud provider to this factory as a consumer and listed it.

Analyze the external concerns and issues that facing a medical smart factory in consuming the cloud in the work with a cloud provider. The internal and external factors were concluded and specified from the PESTEL sides. Also, the study used the linear regression analysis to assess the economic periods of using the developed cloud and study the growth; the analysis assesses the fourth quarter of the 2020 year, the first, second, and third quarters of the 2021 year. The data was collected from the quarterly reports from the official website of the factory and analyzed by Minitab software. The class attribute determined the total profit as dependent on the revenue

of vaccine value, then from functions under classifier selected the linear regression and applied it to the data. Linear programming is applied to key role revenue to increase it within constraints in the operating process.

### **1.9. Structure of the Thesis**

**Introduction:** It provides an overview of this study in general; it represents the scope of the research topic. It supplies a general understanding and deep knowledge to highlight the significance of the topic obviously through describing the purposes of the research, main and secondary questions, and displaying the main hypothesis in the study and secondary hypotheses.

**Literature Review:** It presents earlier research and studies and summarizes the history of the study. It also presents the importance of the study to a particular area of research and other publications approximately the related study.

**Research Methodologies:** This chapter reviews the methods that were used to manage the study, with more details about the SWOT/PESTEL analysis. Also, it presents how to apply the linear regression analysis to the dependent and independent variables. Besides, it also presents the application of linear programming in order to increase the profit within limitations.

**Implementation and Results:** Theoretically, the study got a combined view of the internal and external resources of a smart factory, threats, and opportunities. Based on analyzing the different factors to obtain a holistic view of possibilities and threats that facing a smart factory that uses the cloud. Practically, the annual reports have been studied by this study and extracted the overall profit of the factory with the revenues from the main components of the company. The variables were conducted using Minitab program and Solver add-ins to report numerical relationships accurately and address all the relevant information to all the objectives of the research.

**Conclusion:** This section aims to indicate the extracted results that were established about the practical and theoretical of the literature review and the potential contribution to academia and the industry field.

Recommendations: The last section presents diverse suggestions for this study or similar research under this part based on the conclusion results. In this way, the study yields to its ending.



## **2. LITERATURE REVIEW**

Technology has the power to do many aspects, and changing the world is one of them. The people living in the 2000s are privileged; they are alive where science and technology are exposed and replaced by the exhausting of the comfortable equipment, to make the standards of life easier. The technology accustomed the road to be paved for humans to inspire for more innovation.

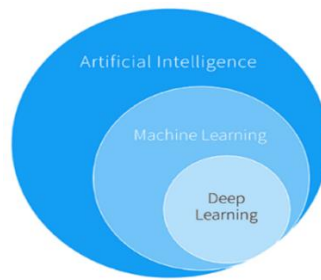
### **2.1. The Artificial Intelligence**

The age of artificial intelligence is already upon us, taking over many functions that were once relegated to humans. People use artificial intelligence almost every day when they talk with an automatic phone system, ask for orientation on the phones, or obtain real-time traffic from Google map alerts on the GPS.

#### **2.1.1. The Definition of Artificial Intelligence**

(Nóvoa et al., 2020) presented the definition as one the sciences refer to program the machine to act as human actions. Artificial intelligence technology is founded in mid of 20th, the idea started from a chess game (*Artificial Intelligence - Alan Turing and the Beginning of AI*, 1998). (Marcus et al., 2000) arguing requires attention to development in this field and the new generation of AI may surpass the human brain in the next future.

### 2.1.2. The Structure of the Artificial Intelligence



**Figure 2.1:** The structure of the AI

(Serokell, 2020) presented that there are three different terms of artificial intelligence (AI), machine learning (ML), and deep learning (DL) mean as in Figure 2.1:

- Artificial Intelligence is the science to build intelligent programs or machines that solve problems creatively.

- Machine Learning is a part of AI which provides a system able to learn automatically and improve its experience without previous programmed neural networks that assist in solving problems.

- Deep Learning is a subset of ML, which uses neural networks to analyze factors with a structure that is similar to the human brain neural system.

### 2.1.3. The Stages of Artificial Intelligence

The steps of development in AI are three stages:

- Artificial Narrow Intelligence (ANI) is a narrow type of step in AI development, the current applications of AI with limited ability in one task (Ben Goertzel & Cassio Pennachin, 2007).

- Artificial General Intelligence (AGI) this step requires more time to apply in life. At this stage, AI techniques are working at the level of the human brain (P. Wang & Goertzel, 2007).

- Artificial Super Intelligence (ASI) is the upper level in the development of AI, when the AI surpasses the mind of a natural human inability (*A Model of Pathways to Artificial Superintelligence Catastrophe for Risk and Decision Analysis: Journal of Experimental & Theoretical Artificial Intelligence: Vol 29, No 2, 2017*).

#### **2.1.4. The Types of Artificial Intelligence**

There are four types of AI:

-Reactive machines

The most basic type of AI system is purely reactive, and it does not have any concept of the past, nor any memory of what has occurred before. This type of intelligence involves the computer perceiving the world directly and acting on what it sees. These methods improve the ability of AI systems to play specific games better, but they cannot easily change or be applied to other situations, cannot function beyond the specific tasks they are assigned, and are easily fooled. Deep Blue, IBM's chess-playing supercomputer, which beat international grandmaster Garry Kasparov in the late 1990s, is the perfect example of this type of machine (Hedtstück, 1990).

-Limited memory

Class II of AI contains machines that can investigate the past, the self-driving car is an example of limited memory. Pre-programmed car in self-system and covers the marks of the road as traffic signal lights or people lane, and other important elements, like curves in the road. These simple pieces of information about the past are only transient. These are used in the light signal change or to prevent being hit by another car (Johnson, 2020).

-Theory of mind

This means the awareness of emotions and feelings in affecting the behavior of general creatures. This is an important point for humans in societies because allowing them to have thoughts that are related to society, the difference between the machines that are used right now and what will be in the future. The devices and machines will be more advanced and developed (*An Introduction to Artificial Intelligence, 2020*).

-Self-awareness

This type extended from the theory of mind, and this is the last step of AI development. This is about systems that can self-forming. AI researchers will build machines that have self-awareness. The build of machines that have self-building is remote, the sight should concentrate on memory understanding, and build learn from former experiences. The design of new machines should be exceptional in the classification (“8 Examples of Artificial Intelligence in Our Everyday Lives,” 2021).

### **2.1.5. The Benefits of Artificial Intelligence**

The AI scope in innovating and enhancing is enormous changing in diverse ways in the future of the world, many benefits from AI are redesigning the known world to humanity.

-Automation

Automation benefits impacted service industries, for instance, the production process, transporting and do it the efficient way in the high productivity by using specific raw materials. It increases the quality, reduced process times, and superior safety. This can provide resources to use in more important works (Mercer, 2021).

-Made a smart decision

The management made decision-making by AI is smart. The management of AI in data systems coordinates delivery then decides the trends and develops data to provide prediction and quantify it to build the best decision. AI is not programmed as human feelings, it will not bias to a specific side and will make smart decisions (Taylor, 2021).

-Enhanced customer experience

The firms that use AI in reply to the customers' requirements provide a rapid solution effectively. This way can decrease the responsibility for the customer care center and increase the productivity of workers (Ruiz, 2021).

- Analysis of the research and data

The analysis data from AI technologies more efficiently than analyzed by a human, it also can predict models based to understand potential outputs in different scenarios. And the advanced capabilities in the computer system can speed up the analysis for researchers in manufacturing (*Transform Your Data Analysis With Artificial Intelligence*, 2020).

-Increased the efficiency

The AI system can introduce the service's 24-hour with the same performance throughout the time. The repetitive assignment will not affect AI tools neither tired nor bored. The productivity will increase and workers can do other important work or work required to do manually (*How Artificial Intelligence Increases Business Productivity - Business 2 Community*, 2018).

#### **2.1.6. The Obstacles of the Artificial Intelligence**

The drawbacks of AI require more ambition to face it and obtain the hold of top power of the benefits of AI in the business work and several firms by addressing it and stated it by researchers in various topics related. The following are more common:

-Bias

(Villasenor, 2019) discussed bias challenge a common obstacle to using AI is the bias in exploring and studying the data. The study based on recent trained data, if it is negative will lead to connecting laced with racial or religious aspects. The requirement is to train AI technology in a positive that did not affect bias points and provides fair decisions.

-Integrating AI

The AI requirement must be compatible with present programs and integrate all techniques with AI. Therefore, it requires suitable infrastructure and provides storage data for its output. And train the workers to new requirements in a firm (Wirtz et al., 2020).

-Computing power

Challenge of facing huge computing force, different volume of processing in the past. The build of AI and utilizing deep learning techniques are not mentioned as another obstacle in the AI sector manufacturing. The funding for this volume of computing not is easy (Marr, 2017).

-Legal issues

The latest challenge in the world of AI technology is the legal part that requires one to be wary of it. The divisions of different data do not affect the people, but if it is sensitive data, and then collect, it might violate the laws or legal issues in the world (Rodrigues, 2020).

## **2.2. Cloud Computing**

This chapter introduces cloud computing from different sides definitions side and the main service models. Also, discussion of the benefits of adopting the cloud on the business side. On the other hand, introduce the obstacles and issues of the cloud. Finally, a review of recent work related to the basic elements of this research.

### **2.2.1. Definitions of Cloud**

The term cloud is a popular practice and means the availability of computer system resources on-demand, particularly, is to provide different services through the Internet as storage of the data and computing power, without direct active management by the user with very minor human intervention, demonstrated through a cloud provider in the commerce by 2006 after Amazon presented Elastic Cloud, as a novel model in business in the cloud field (*What Is Cloud Computing*, 2021).



**Figure 2.2:** A mind map of cloud (“The Cloud Computing Mind Map,” 2010)

Figure 2.2 above demonstrates the benefits, service model, risk and drawbacks, deployment, characteristics, and actors of the cloud term as a mind map.

The requirement for a standard definition for cloud computing motivated organizations and researchers to invent a universal meaning of the expression. The cloud service is a novel style of computing; the service is scalable and more flexible in capabilities in IT components. The features presented by the cloud are several and different. For instance, Google introduced a storage service, and the public cloud technology was used to support external customers. Using the public cloud in services increases the number of jobs and results in different and new types of economies that are scalable and flexible in the base of resources and shared, this leads to an increase the revenue and reduces the cost. This also implies using the services as a platform or infrastructure of the cloud without guaranteeing the location and storage (*Definition of Public Cloud Computing - Gartner Information Technology Glossary, 2021*). Cloud computing increased day by day and has become more popular and developed. The growth of business and development demands a large computational power and

massive data storage systems (Ranger, 2018). Organizations use the cloud to transfer the data safely from the physical to the cloud resources to help access different sites. Industry based-cloud computing is one of the fastest businesses in growth because of its characteristics that have.

### **2.2.2. The Characteristics of Cloud**

The major characteristics of cloud computing are presented in (Mahali, 2019) as follows:

- On-demand self-service
- Simple maintenance
- Scalability
- Economic
- Reporting service
- Security
- Automation
- Resilience
- Ubiquity

### **2.2.3. Cloud Deployment Models**

This is defined as a model of cloud that satisfies the requirement of the organization. The cost is the more important side in deciding the type of deployment and choosing it. The model's deployment types as in (Rountree & Castrillo, 2014):

- Private cloud

This is specified to one organization and the management may be from the side of the organization or a third party. This type may be located at the organization or out of it.

- Public cloud infrastructure

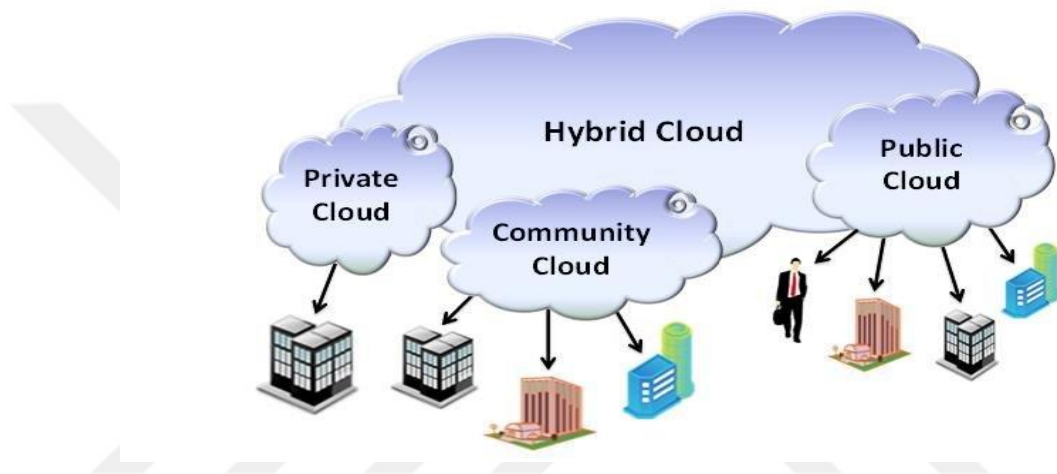
The owner will be an organization that sells services related to the cloud. It is available to the public or large firms in the business.

#### -Community cloud

The one infrastructure shared between several organizations. And the management from the side of organizations that are shared or a third party. The locates of the cloud may be in the workplace or out of it.

#### -Hybrid cloud

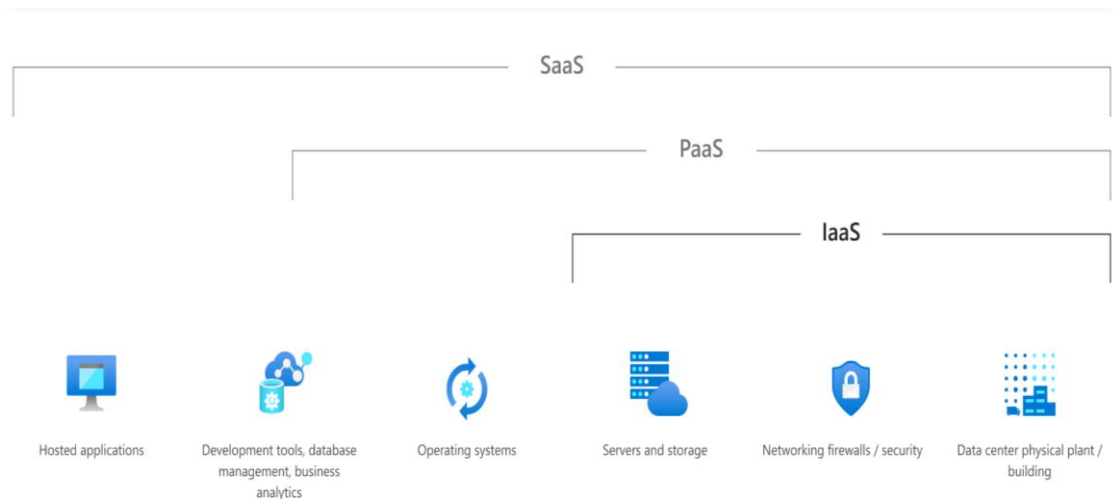
The Hybrid is a structure of many clouds with different types, it remains individual entities but is tied together by standardized technology that enables data portability. The following Figure 2.3 shows the deployment of the cloud.



**Figure 2.3:** Cloud computing deployment (Bamiah, 2015)

#### 2.2.4. The Categories of the Cloud Computing

The services provided by the cloud are divided into 3 fundamental categories. First, is the infrastructure service. Second is platform service, and the third category is software. There is a new service type is a function service (Cloud Computing | Types of Cloud Computing Services | ESDS, 2021). Figure 2.4 presents the software service is on the upper because users interact with the software on the cloud, neither the platform nor infrastructure that runs it. The service of the platform permits users to build and deploy different applications. The physical data center and hardware required to power the cloud are located in the infrastructure.



**Figure 2.4:** The categories of the cloud

Infrastructure as a Service (IaaS) contains the root of building the cloud fundamental, the delivery of the cloud service as renting IT infrastructure. Also, this service introduces various networking features. IaaS comprises services that are based on the cloud on a pay-as-you-go model and it allows the user to build new technology (*What Is IaaS?*, 2021).

Platform-as-a-service (PaaS) refers to introducing the tools on-demand in part of developing, or testing functions, presenting the applications, and managing the service related to software. The scalability of this service provides a framework for specialists in IT technologies to build new applications for smartphones or create websites. The providers of these services in PaaS manage the infrastructure and all concerns related to these cloud services (*What Is PaaS?*, 2021).

Software-as-a-service (SaaS) is providing on-demand software through cloud subscriptions using any device that is connected to the Internet. Software sellers host the servers and present after-sale services like maintenance and protect the databases. (“Software as a Service,” 2021).

Functions as a Service (FaaS) is a category of cloud that adds a layer to PaaS to separate the developers in the stack to execute code on the edge, due to the term service of FaaS being serverless. The responsibility of virtual servers and applications runtime

on the vendors' side, FaaS does not consume IaaS resources, and this reduces the cost (Cloud Computing / Types of Cloud Computing Services / ESDS, 2021).

### **2.2.5. Cloud Computing Actors**

The actors in the cloud may be a person or organization that profession in the performing or sub-process actions in the cloud. The cloud actors in (“Cloud Stakeholders as per NIST,” 2018) are five performers :

- The users of cloud

The individual or firms who utilize the cloud even governmental or non.

- The provider of cloud

The vendor or who introduced the cloud services.

- Cloud auditor

The part from the cloud system that audits and evaluates based on different factors the service.

- Cloud broker

A party middle between consumers and vendors in the cloud world to manage performance.

- Cloud carrier

The channel transporter between the cloud introducer and the users.

### **2.2.6. The Benefits of Cloud**

The cloud service introduces many benefits to the consumers and the increase in the number of devices that enable the Internet service what the cloud requires to use the service. In this context, the different benefits of this subject are present clearly in the business as mentioned by (Employment, 2011) are:

- Decrease the costs of use

The most important benefit of cloud use is a return of money for business firms. The responsibility to hold and maintain the system at the shoulders of vendors, even the development, provided by the providers of the service as automatic updates service.

The causes of reducing cost are many, mentioned, first of all, the scalability extends or decreases the uses; the utilization is based on work requirements. Second, there will be no fees for experts in the systems, the development, and upgrades introduced by vendors, and the service to protect the consumer uses.

-Protect business

The continuous work in the disasters and unusual times as electricity issues or earthquakes. The continuity in the previous conditions and protect them from damage are exceptional features in these cloud systems.

-The flexibility and collaboration

The easy access to services provided by the cloud from different locations and several devices are falling under the definition of flexibility and collaboration in the service. The out employees can also enter the database and obtain benefits from using raw data and information.

### **2.2.7. The Challenges of the Cloud**

The most common invalidates faced by the cloud presented in (“Cloud Computing Risks, Challenges & Problems Businesses Are Facing,” 2019) are the issues in our era related to the cloud are mainly in the financial part and not having enough smart required resources are the clearest obstacles that prevent to use effectively.

### **2.2.8. The Trend of Cloud- AI Services**

Cloud computing exploded between 2020 and 2021, as the environment of the work changed to be virtual, the businesses and whole life stand on the shoulders of the technology. By adopting the online environment in life, the firms will focus shift away from the traditional way of work and migrate to cloud tools. Augmenting the abilities of the workforce and hybridizing the process of production and distance learning will remain a key trend. (*A New Framing for Cloud Innovation*, 2021) discussed that the ongoing innovation in cloud services and data infrastructure turned most actions to do online.

The delivery of digital services from using Google search to Instagram filters based on Cloud-AI will undoubtedly see a continuation of rapid adoption and growth. The dependency on cloud services was described by CEO of Google (Sundar Pichai, 2021) as more an effect or more profound than electricity or fire on the society in the next year or beyond. The platforms of machine language require huge power for processing and bandwidth for training data and processing it. Datacenters of cloud make it available to everyone from different levels (*The 5 Biggest Cloud Computing Trends In 2022 | Bernard Marr, 2021*).

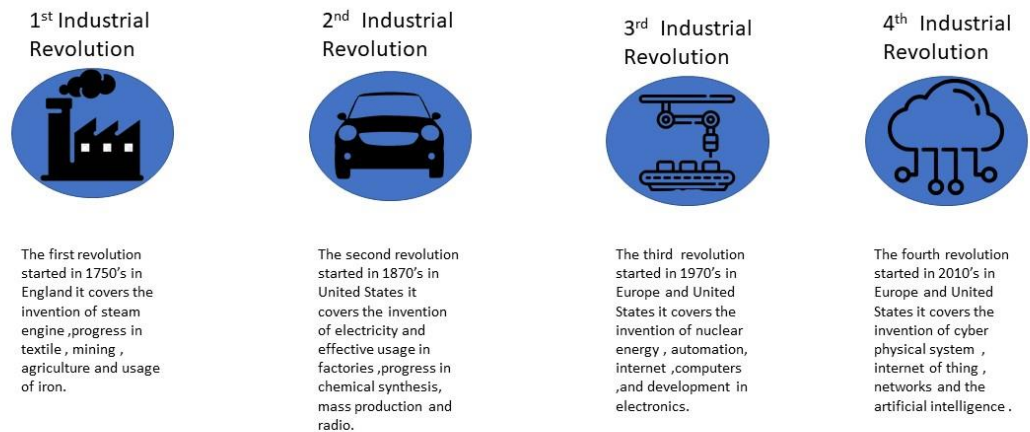
(Advani, 2021) presented Cloud-AI is a strong trend in creative algorithms that permit to do any issue by increasing the accuracy with generative machine learning that can understand human language.

## **2.3. Smart Factory**

### **2.3.1. The Four Industrial Revolutions**

The industrial revolution is the change in the style of life and it had an improvement in the standards of living and became more urban, the dominance of steam engines and progress in the textile economy changed to one dominated by the Internet of Things (IoT) and machine manufacturing (*Industrial Revolution / Definition, History, Dates, Summary, & Facts, 2015*). The first industrial revolution began in England in the eighteenth century, it contained inventions in the steam engine, progress in textile, transport, telegraph communications, dynamite used in fragmentation the rocks, agriculture progress, and the usage of steel (*10 Key Inventions of the Industrial Revolution, 2020*). The second industrial revolution began in the United States in the 1870s it contained inventions in electricity, progress in chemical synthesis, the telephone radio, and effective usage in factories (*Second Industrial Revolution, 2016*). The third industrial revolution began in the United States and Europe in the 1970s it had usage of nuclear energy, contained development in electronics (transistors), progress in automation, and development in robots in production, computers, and the Internet started to appear in the world (“The 4 Industrial Revolutions,” 2019). According to (Lim et al., 2021, p. 0) the fourth one was built on a third, this revolution started in 2010's Europe and the United States. It is called

Industry 4.0 in European title and smart manufacturing in America. It reshapes the life standards and the Internet covering the life on the Internet of Things or the development of cyber-physical systems helps humanity to stand against the physics nature (Greer et al., 2019). Figure 2.5 presents the transaction between the revolutions.



**Figure 2.5:** The transaction between the industrial revolution (*Klaus Schwab, 2016*)

### 2.3.2. Philosophy of Smart Factory

It incorporates the emerging of technical progress to the advancement of the industry to deal with some challenges in the global (“The 4 Industrial Revolutions,” 2019). In this section, the information presented related to the smart industry, the principal features, and the required technologies to build a base for smart factory development.

### 2.3.3. Background and Aim

Society is desiring a cumulative improvement in the quality of life. The industrial revolution is advancing to preserve move with the requirements of the human. The communities have experienced before the 2010s three revolutionaries of industry.

Smart factories help society to continue the improvement in the standards of life, the factory producing high-quality products and creating a better life for the employee's conditions (S. Wang et al., 2016).

(Umair Shahzad, 2012) discussed that the industries contribute to the disruption in the environment, it causes the increase in global warming and pollution in the environment. It consumes coal and petroleum, and this leads to a decrease in the plenty of nonrenewable resources in the world. The industry requires rootable changes in the product; the demand is increased for the production but there is aging in the population. The main idea is to find sustainable manufacturing to address these problems, by this new technical process to build an integrated engineering process and upgrade the production making so that the process be an economic, friendly environmental impact. For the technological process, it must not be economic and vital benefits but also for the world in 3ps; people, profit, and the planet.

#### **2.3.4. The Pillars of Smart Factory**

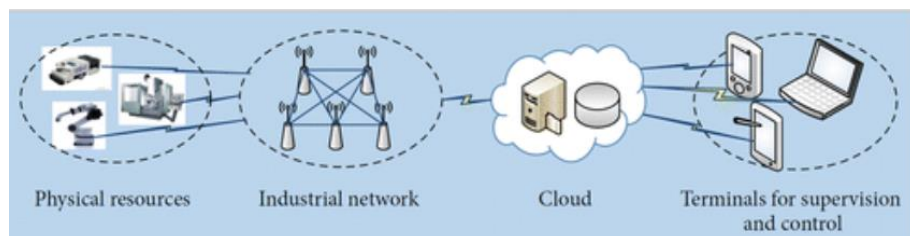
Due to (*How Smart Factories Are Changing the Manufacturing Industry*, 2017) a smart factory is the factory that produces when the pillars of Industry 4.0 are implemented in the process as major data analysis, IoT, clouding and other pillars demonstrated in Figure 2.6 below.



**Figure 2.6:** The pillars of a smart factory (Anand Nayyar & Akshi Kumar, 2020)

### 2.3.5. The Architecture of the Smart Factory

Figure 2.7 below views a smart factory framework, different four layers consisted. The first is, the fundamental physical layer, which provides real-time communication in a network of industries. Second, the networking layer in the industry represents the integration of several kinds of systems and hardware devices technologies, for instance, the connection between the public buses and sensor tracing. And cloud part is a live expression for a network of servers. And the last layer of a smart firm that connects with the people in control and monitoring.



**Figure 2.7:** Smart factory framework

#### -The Physical

This layer consists of diverse types of physical artifacts. These smart artifacts can communicate with each other through the industrial network as smart products, smart machines, and smart conveyors. These artifacts can take part in achieving a system-wide goal (Chen et al., 2018).

#### -The Industrial Network

According to (Shi et al., 2020) it enables infrastructure internal connection and connects with the cloud with the physical layer. The smart factory use IWN it surpasses Ethernet in characteristics.

#### -The cloud

Cloud computing denotes a platform that introduces kinds of features like networking and several applications. Cloud provides smart services like intelligent key manufacturing for agile linkage, privacy protection, data cleaning, and real-time processing (*Remote Sounding of Cloudy Atmospheres. I. The Single Cloud Layer in: Journal of the Atmospheric Sciences Volume 31 Issue 1 (1974), 1974*).

#### -The Terminals Control

This connects the consumers of services with the main factory. The terminals are personal computers, tablets, and smartphones, people have the access to statistics in the cloud, and they apply various configurations or maintenance and identification issues, the remote way through the Internet(Chen et al., 2018).

### **2.3.6. The Challenges of Smart Factory**

Due to the rapid improvement in industry 4.0, the smart factory should have flexibility and reliability, and the industries should produce high-quality standards of products. Modern technological manufacturers bring many opportunities to implement intelligent manufacturing. However, there are some issues and challenges for the smart industry.

#### **1- Intelligent equipment**

Due to the large role of the equipment in the factory, the obstacle of the smart factory has the advanced level of intelligent equipment in manufacturing monitoring, and controlling (Sjödín et al., 2018).

#### **2- Manufacturing data volume**

The mining of a huge size data provided by the machine is a crucial point of use in enhancing productivity and improving production lines (Chen et al., 2018).

#### **3- Deep integration networks**

(Herrmann, 2018) discussed that the IoT enhances the integration between the industry environment and the information. The Wireless Sensor Networks (WSN) should promote continuously in its thousands of nodes to connect them to other sensors. The reliability of the electromagnetic environment and control in machines must provide the requirement of the smart factory.

The reliability of power is the most obstacle in the network deployment effect of the Industrial Wireless Sensor Network (IWSN) which is used to enhance the process by distributing the sensors and connecting between them (Xu & Hua, 2017).

### **2.4. Smart Factory Example: Pfizer**

Pfizer is a firm in the pharma field that was founded by Charles Pfizer and Charles F. Erhart. The head office is located in New York, USA1849 (*Who Owns Pfizer and Where Is the Vaccine Made?*, 2020). The logo of the firm is in Figure 2.8 below.



**Figure 2.8:** The logo of Pfizer company (“Pfizer,” 2021)

#### **2.4.1. Background and Purpose**

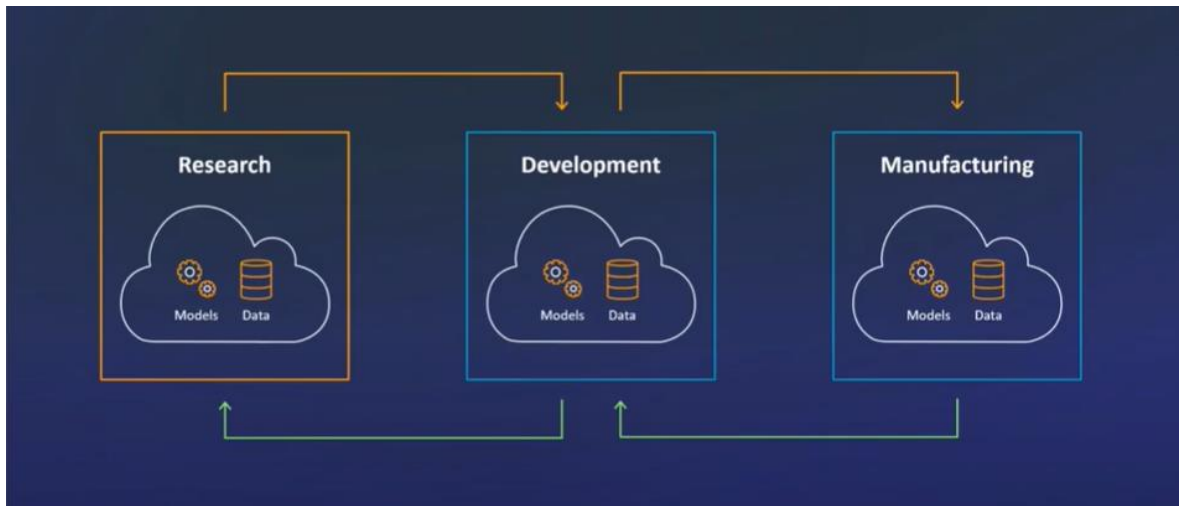
Pfizer term named after its co-founder, Charles Pfizer. The American firm for pharmaceutical and medical products. Corporation Pfizer Inc. is a premier firm in the pharmaceutical industry, Pfizer factory manufacture medicines and produces vaccines (“Pfizer,” 2021).

(Bourla,2021) asserts that they apply deep science in the pharma and chemical industry to introduce high value with competencies of Pfizer capabilities to people. The value introduced by Pfizer aimed to manufacture top-quality pharma industry health care products (*Pfizer Company Fact Sheet / Key Pharma & Consumer Health Products / Pfpfizeruscom*, 2021).

Against a complex health landscape, Pfizer is committed to global health to help strengthen health systems and improve the quality of healthcare services for patients. And Pfizer's responsibility is also to protect people and the environment by embracing the full product life-cycle by producing green products (*Protecting People and the Environment / Pfpfizeruscom*, 2021).

#### **2.4.2. The Reasons for Moving to Cloud**

The product flow from the research into the development to the manufacturing is linear as the Figure 2.9 below, so there is no feedback loop from manufacturing to development and from development to research. The R&D management in the firm wants the system to bridge this problem (AWS Events, 2020).

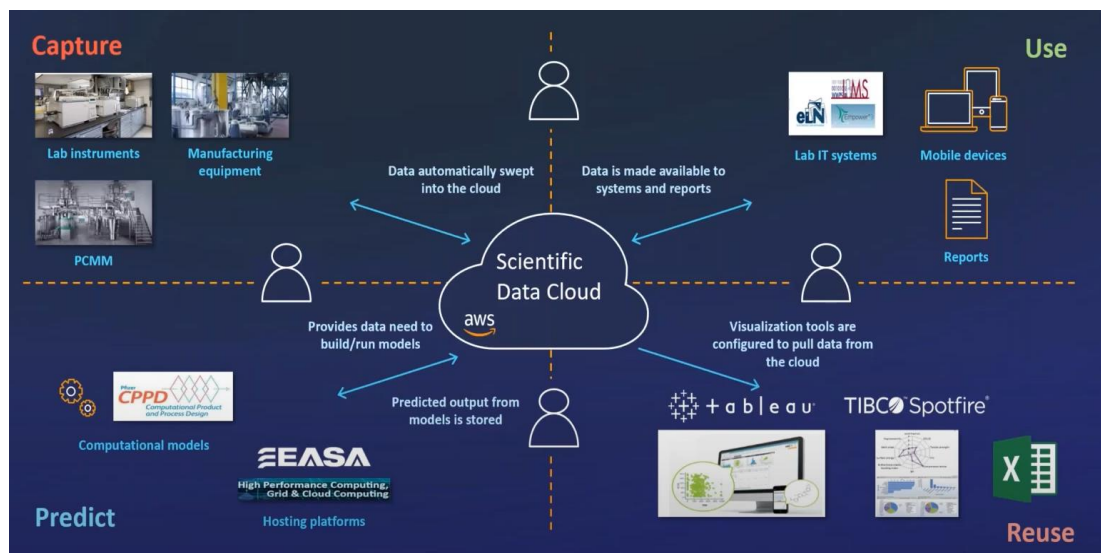


**Figure 2.9:** The path of Pfizer manufacturing

(Bulusu,2020) asserted also, that the regulatory agencies are asking for raw data that cannot be found quickly during a regulatory inspection. And increasingly, there is a growing set of concerns from the agencies regarding the product quality aspects offered by therapists. From speed respective, the pressure on the pipeline is increasing to generate new medicines, and thinking high throughput data analysis will enable simultaneous acceleration of multiple products through the pipeline. Rapid access is the main goal of the scientific data cloud (SDC) to introduce predictive models results from high-level quality data in faster progression of the portfolio. New scientific insights are required to advance to the portfolio. On-demand analysis of relationships between datasets like API particle size is required (AWS Events, 2020).

### 2.4.3. Pfizer Vision

SDC open data lake architecture is built on top of Amazon Web Services, which allows for the platform to scale dynamically as data volumes increase and analytical requirements become more complex. The group of developers in Pfizer looked to convert all manual information exchanges that cross into four quadrants shown in Figure 2.10. The data generated from lab instruments and manufacturing equipment is automatically swept into the (SDC), and then may process, reprocessed or formatted in different ways. The data is available to several tools to analyze in cross enterprises. The data is stored in spreadsheets to be used by researchers and experts in modeling and simulation works (*Shining a Light on Dark Data | How Pfizer Collects Analytical Knowledge for Access and Reuse from Anywhere, at Any Time*, 2021).



**Figure 2.10:** Pfizer vision (AWS Events, 2020)

Pfizer utilizes Komprise, the industry leader in the management of the data, as a partner of AWS. Komprise helps Pfizer to manage the cold data and access it quickly from the cloud data without knowing whether it is cold or hot data. Komprise helped Pfizer stop 20 years preserve cold data and saved 75% on storage of hold the data (Komprise, 2021).

#### 2.4.4. The Continuity of the Successful Journey of Pfizer

Speaking of the path of Pfizer's successful history, the reader should think of the number of accomplishments this company has made and the efforts that employees have inserted into positive planning, persistence in working on valuable strategies, and harnessing this knowledge to advance products in healthcare right from the start.

The continuity of playing a key role in the medicine region of Pfizer started in the 19th and continues by manufacturing pain killers, anesthetics, and antibiotics. The firm charged during World War 1 the medicine such as iodine and disinfectants. Also, preservatives reduce the growth of bacteria, and this impacts the shipping of food to different countries of the world. Pfizer plays a role in manufacturing the pain killers such as morphine and chloroform. The achievements continued from that time until the emergence of the 2019 Coronavirus (*A History of Pfizer -*, 2020).

Pfizer is on the titles far frequently. The greatest achievement in COVID-19 is what made Pfizer atop other specialty competitors. Disruptive technologies played a

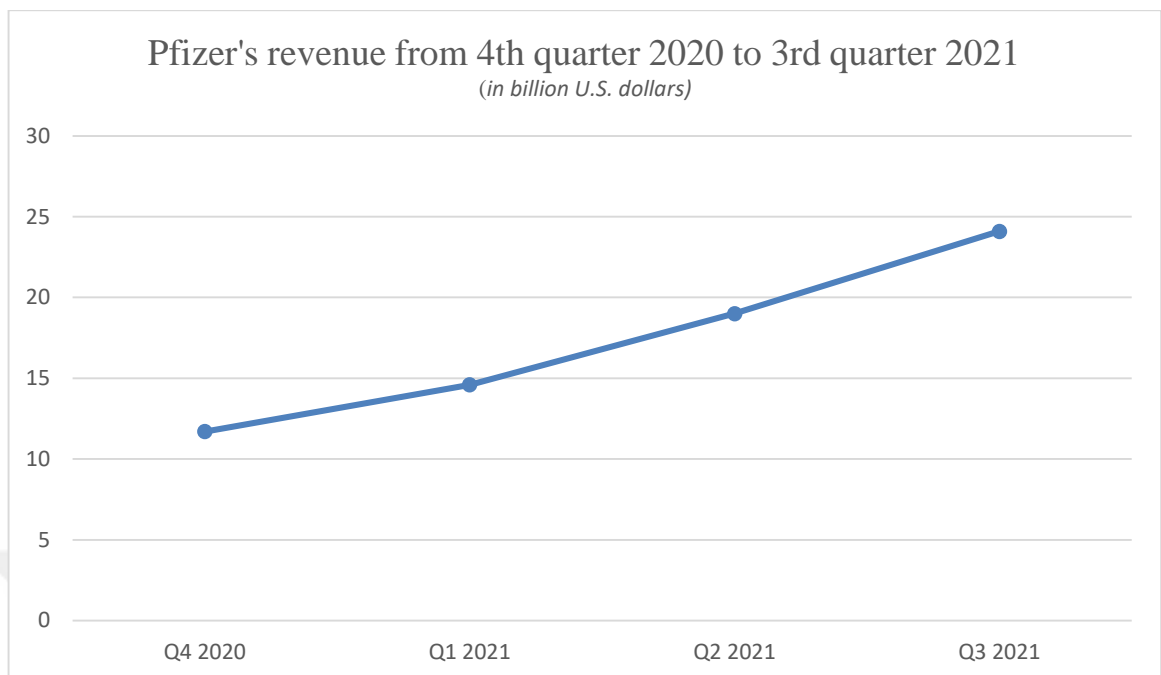
role in producing high-level effectiveness to the spreading coronavirus and decreasing the impact of the virus (*Real-World Evidence Confirms High Effectiveness of Pfizer-BioNTech COVID-19 Vaccine and Profound Public Health Impact of Vaccination One Year After Pandemic Declared* | Pfizer, 2021).

Also, taking the COVID-19 vaccine provides some natural protection or immunity from re-infection with the virus that causes COVID-19 (Vaccines beat natural immunity in fight against COVID-19 Sep 10, 2021). Generating a novel vaccine from scratch requires considerable time it may take a long decade in science to produce. The optimal use of artificial intelligence and the core researchers that worked day and night in Pfizer's team are the main roles to obtain this point of success.

The usage of cloud computing played a specific part, enabling Pfizer to lead at the speed required in the response to the COVID-19 pandemic (*Pfizer's Digital Strategy and Transformation*, 2021). A novel coronavirus 2019 generated by disease with the acute respiratory coronavirus 2 syndrome (SARS-CoV-2) strain was issued by the WHO on 11 February 2020 (Sharma et al., 2020). Using the cloud in scientific research provided access to an unattainable level of computing power the previous, it enabled the chemists in Pfizer firm to search and analyze the internal and external compound collection that pass a billion molecules in hours, this process took a long week to be analyzed.

The company and all the employees are doing their utmost to obtain approvals regarding the drug produced by Pfizer, which will treat the effects of the Corona pandemic on former patients, in addition to developing subsidized vaccines and developing vaccines for young age groups. The employees of the company are doing continuous work to reduce the impact of the variants from the Coronavirus, the disease of the age at present.

In addition to the prestige that Pfizer achieved among the most prestigious industrial companies, the company achieved billions in profits by producing the Corona vaccine. The following figure shows the profits of Pfizer since the start of its vaccine production from the fourth quarter of 2020 until this study was conducted after the third quarter of 2021.



**Figure 2.11:** Revenue of Pfizer since the vaccine was developed(*Pfizer Inc. - Financials - Quarterly Reports, 2021*)

Previous Figure 2.11 indicates the firm earned 11.7 billion in the fourth quarter of 2020, then the revenue increased to 14.6 billion in the first quarter of 2021. The revenue of the firm reached \$19.0, and \$24.1 billion of dollars respectively in the second and third quarters of this year.

#### **2.4.5. The Bright Sides of Pfizer**

The advanced technical indicates that the smart factory exhibits a promising production model. The smart factory leads to diverse advantages and benefits which can cope with the surrounded challenges to the world by producing efficient and profitable products. The next points discuss some merits that the society can obtain benefit from.

##### **- Productivity**

The factory can produce small lots with more efficient products compared with traditional factories. The optimization of the production process by helping the feedback of large data to obtain the maximum utilization rate of machines and raw materials. Also, the minimum time to set up time the process of machines when switching between different types (*Manufacturing & Supply Chain Excellence – Pfizer Annual Review 2017, 2017*).

##### **- Profitability**

The decreasing of the cost of the operational process and production accurately in the firm led to an increase in the investment of the owners, by initializing new factories or branches will bring more benefits to the jobless (*Pfizer Global Sites / Pfizer, 2021*). Additionally, Pfizer's firm increases the salary and adds more advantages to its employees (*Our Focus on Employee Growth and Development / Pfizer: One of the World's Premier Biopharmaceutical Companies, 2021*). On the other hand, improving the economy of the United States and the whole world by exporting the different drugs and healthcare products.

##### **- Comfortability**

The machines are staff friendly, the equipment operates automatically and workers do not operate in routine tasks (Yerema et al., 2021). The analysis of major data provides powerful software tools with intuitive and flexible interface procedures in maintenance. The repairing can do remotely by interacting with people and machines through the cloud (Tyer, 2018).

- Efficiency

The most important point in medicine manufacturing the smart operational work by using the determinant amount of ingredients (Mishra, 2021), the safety and accurate information about the drugs are blinking merit of Pfizer in developing medicines and vaccines. Stable product quality is based on using big data technology to establish specific knowledge about the production process and guarantee the product in various cases (Olson, 2021).

#### **2.4.6. The Development of Framework**

In the industry, scientists raced to introduce the products at a record-breaking speed, as Pfizer turned to do an innovative action by developing the tools that were used in the factory. Pfizer looked to be a historical icon in the development of medical products when the team of the firm faced an incredible challenge to make a vaccine for Covid-19 in a fraction of time to protect human lives.

The key factor that helped the Pfizer team to develop a vaccine in a short time was the past investment and keeping abreast of recent technological developments by building a digital infrastructure. The company had started the development of the research and using the digitalization in its operations by using artificial intelligence technology in the laboratories. The company used artificial intelligence to analyze millions of signals by predictive real-time models for 46000 person files in six countries in 150 different locations while the vaccine clinical trial. The advanced smart framework in the factory from the mixing of AI technology is the reason behind the hitherto the success and the teamwork is not able to do it as quickly as did without the advanced infrastructure in the company (Bourla, 2021). Artificial intelligence is a base for numerous advanced computing solutions in the smart framework in the firms. As AI covers the two issues in the pharmaceutical firms are machine learning where it applies the analysis for statistical data and studies the pattern matching trained samples. In addition, it can process the natural language for human words to get its meaning and develop the sentences to reflect the human writings (Fonseca, 2022).

The development of new medicines required terabytes or petabytes of data at each level of testing to deliver safe products. This amount of data introduces additional insights that were never available before performing advanced calculations for this data and this is the core of artificial intelligence. The application of math to this huge volume of data needs to be clear and checked by experts by monitoring the results based on trained data. The aim of this studies to get true mining for the tested data to produce the recommendations from the human developers in the medicine development department in the factory (Braylyan, 2021).

Pfizer collaborated with another firm that can affect positive reflects on the development process by organizing and cleaning duplicate information generated by artificial intelligence tools. The external partner from premier technology companies such as Saama Technologies is the number 1 cloud platform specialized in AI-powered clinical analytics that meets the needs of the Pfizer context. The effect of using the cloud with AI technology has a significant impact on the speed of moving between the manufacturing stages, inspecting the inconsistent data, and making the correct decision as soon as possible. Also, the clinical output data has high quality even from the first pass (Zambas, 2021).

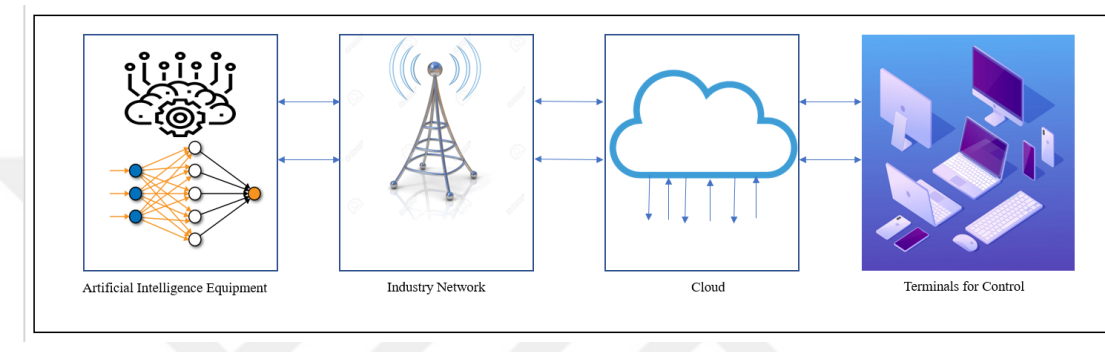
The online service of collecting health records, using the telemedicine resources and electronic prescriptions provided by the talented partners from Saama cloud provider company impacted the level of the efficiency of the process in Pfizer. The collaboration between the different technology and with an innovative framework in Pfizer firm by using a secured server of cloud may produce viable advanced tools that aim to save the life or produce a high level of living for the human. Also, the time saving for the experts and researchers to focus on issues that require pivotal thinking and to help to get the patient's needs deeply (Yoshida, 2021).

The ideal use of AI in the novel framework from giant the United States Pfizer led to the development Comirnaty vaccine, where the Covid-19 vaccine product boost the revenue to \$81.29 billion for 2021 and reported \$21.98 billion in the net profit. Besides, Pfizer paid billions of dollars to achieve this level of success and reach the top one in the medicine development without a guarantee that this investment would pay off. The unprecedented increase in revenue and the prestige of Pfizer over other firms make the team-work proud to deliver the first vaccine and the first oral treatment

authorized by FDA for the deadly Coronavirus. The optimization of AI tools was a key role to achieve this mission (Burla, 2022).

## 2.5. Conceptual Framework

In this research, a quantitative and qualitative approach was used to study the relationship between the variables, as provided in Figure 2.12.

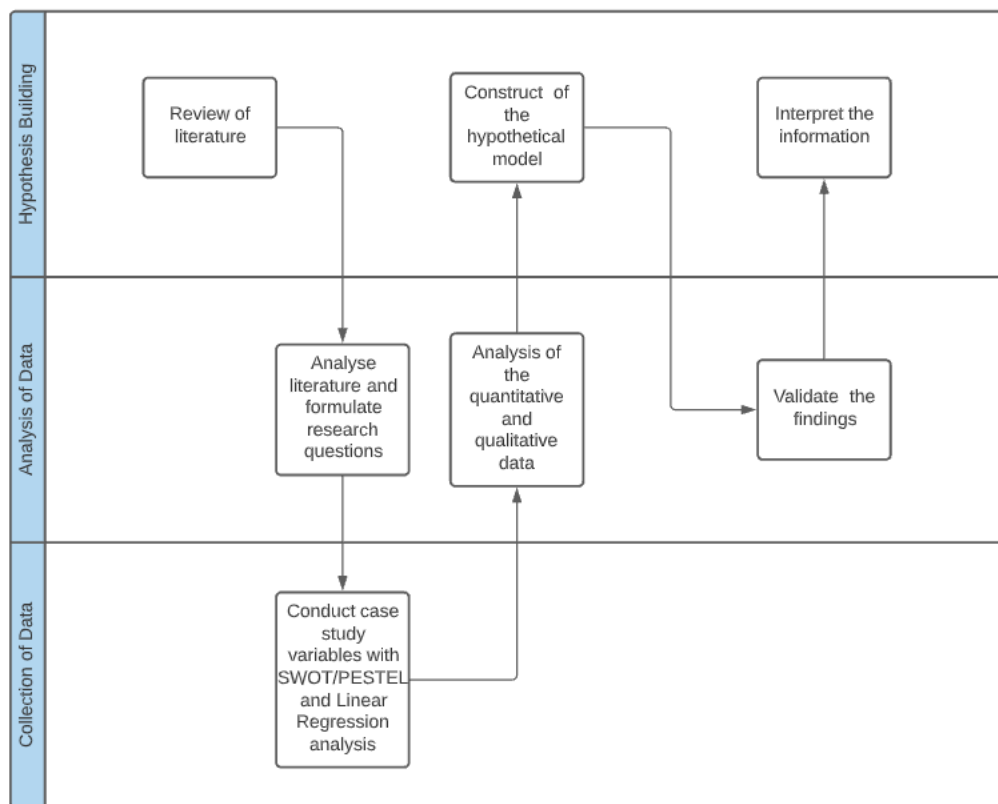


**Figure 2.12:** Conceptual framework

The study structure presented in the previous figure was adapted from (Burla, 2022) who stated that there was an increase in profit after the development of Pfizer's framework. In addition, (Kazmi et al., 2016) investigate the relationship between cloud service impact and economic growth. Other than that, (Wan et al., 2018) stated that the smart factory using AI based on cloud service can provide reliable and efficient productions when it uses the cloud with advanced technology equipment.

### 3. METHODOLOGY

The study utilized the qualitative and quantitative methods of data collection by conducting the SWOT/PESTEL and regression analysis of a smart factory as presented in the following flowchart Figure 3.1:



**Figure 3.1:** Flowchart of the methodology

#### 3.1. Chapter Outline

The aim of this research is to obtain the effect of cloud computing on artificial intelligence equipment that will affect smart factory management which relates to

economic growth and distinctive factors of the case study within the context of medical sectors. This chapter investigates the suggested framework and its hypothesis, the chapter explains the population of the research, SWOT/PESTEL, and linear regression as a research method to test its conceptual framework. The chapter throughout its sections shows an investigation of the methodology steps and validates the intended framework. A factory was chosen as a multinational corporation as a case study based on the availability of the related data as a famous business firm. The quarterly reports are available under the official website as the most comprehensive source for the required data. To reach the target of this research, SWOT/PESTEL and linear regression are considered to be strong-established techniques for collecting and obtaining data. SWOT and PESTLE analysis together permit the research to obtain a broad view of the internal and external resources, threats, and opportunities. On the other hand, based on the available published data on the website of a factory, linear regression analysis was used to build a relationship between the overall profit and the revenue from the main six products of the firm and to determine what is the main influencer in the total profit by mixing cloud and artificial intelligence tools. Also, linear programming analysis was used to improve the impactful product to achieve and maximize profit in an operational process within constraints in inventory components.

### **3.2. SWOT/PESTEL Analysis Steps**

SWOT and PESTEL analysis are complementary to each other as two sides of one coin. They are useful when it comes to making a systematic evaluation for any project. This analysis helps make a proper decision about the alternative choices, boost the competitive advantages and manage the novel innovation. SWOT analysis is to demonstrate the internal and external factors. SWOT acronym stands for strength, weakness, opportunities, and threats. Also, PESTEL is used to assess the external factors that affect the firm, the impacting factors are political, economic, social, technological, environmental, and legal sides. SWOT and PESTLE analysis together permit the business firms to obtain a merged view of the external and internal resources, threats, and

opportunities. The two frameworks analyze the environment based on different factors, so the managers who study the firm can obtain a holistic view of the possibilities and threats that exist.

The steps of SWOT/PESTEL analysis of firm to broader view can investigate as follows:

#### 1-Data collection

To obtain the most out of the analysis, decide on the objectives to evaluate a process in the factory. Understand the factory's business, industry, and market. Also, conducting the research on the market and determining its competitors.

#### 2- Brainstorming to identify factors

There is a broad range of environmental factors from cloud service providers that affect the factory as a consumer. First, the internal factors; strengths, and weaknesses will discuss from the political, economic, social, technological, environmental, and legal factors. The second step is discussing the external factors; opportunities and threats will discuss from the PESTEL analysis categories. Brainstorm to illustrate the most notable factors that impact the consumer factory from cloud provider company. The aim is to define particular factors under each category that are demonstrated to have the most influence on the factory, comprehend the impact on diverse workstations and explain the consequences.

#### 3- Discussing the factors under each category

Listing the external factors of PESTEL analysis that may affect the factory from two sides of SWOT analysis in external and internal capabilities, the study evaluates firm directions and the factors that influence the success and impact the performance of the factory's operational and entrepreneurial works. The connecting between two of these analyzes are useful to have an objective overall look at the world in which the factory

exists and understand its competency. The following Table 3.1 is a template to investigate the relation between cloud providers and cloud consumers to discuss the important categories in SWOT/PESTEL analysis.

**Table 3.1:** Template of SWOT/PESTEL

| <b>Features</b> | <b>Strength</b> | <b>Weaknesses</b> | <b>Opportunities</b> | <b>Threats</b> |
|-----------------|-----------------|-------------------|----------------------|----------------|
| Political       |                 |                   |                      |                |
| Economical      |                 |                   |                      |                |
| Social          |                 |                   |                      |                |
| Technical       |                 |                   |                      |                |
| Environmental   |                 |                   |                      |                |
| Legal           |                 |                   |                      |                |

### **3.3. Linear Regression Analysis Steps**

In this study, the linear regression method depicts a smart factory's total revenue and investigates the factors that play a key role in the profit. The goal of this analysis is to analyze case study data for the fourth quarter of the 2020 year up to the third quarter of the 2021 year. The main elements in this study are the information of the financial reports of the firm and the analytical tools used to check the study.

The case study is one of the biggest pharmaceutical firms in the USA and the world for medical products. The business products are categorized into six main products, which are vaccines, oncology, internal medicine, rare disease, hospital, and inflammation & immunology.

Data mining in machine learning uses to find patterns and extract relations based on previous data, like mining knowledge from data to make business decisions that can either increase the profit or decrease the cost. There are different types of tools in machine learning R, Data Science Studio, Minitab, and Weka ("Data Mining," 2021).

At the beginning of this research, the following tools for this analysis should be presented and explained. The following are the measurements and statistical techniques used in the study:

Regression analysis:

Regression analysis is a set of techniques and statistical processes used in predicting and investigating the relationship between variables (Gallo, 2015).

Simple linear regression:

Simple linear regression is a model to estimate the relation between two quantitative variables. The equation of simple linear regression is expressed as the following:

$$y = \beta_0 + \beta_1x + \varepsilon \quad (3.1)$$

$\beta_0$  as the intercept and the slope  $\beta_1$  unknown value and  $\varepsilon$  is a random error (*An Introduction to Simple Linear Regression*, 2020).

Multiple linear regression:

A statistical technique to estimate the relation between the response of a specific variable to several variables, the variable  $y$  may be correlated to  $k$  regressors.

$x_1, x_2, \dots, x_k$ , and so on.

$$y = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k + \varepsilon \quad (3.2)$$

(*Multiple Linear Regression (MLR) Definition*, 2021)

Least Squares Estimation:

The least-squares technique is used to predict the parameters  $\beta_0, \beta_1, \dots, \beta_k$  by minimizing the squared variances between the observations  $y_i$  and the straight line (*Least Squares Method Definition*, 2021).

R-squared:

R-squared is a statistical measure that represents how close the data is to the dependent variable defined by the variable in a regression model. It is also known as the percentage of the response variable curve that is defined by a linear model.

$$R - \text{squared} = \frac{\sum \text{of squares of residuals}}{\text{the total sum of squares}} \quad (3.3)$$

R-squared value is  $0 < R\text{-squared} < 100\%$ . The 0% as the minimum value means the model explains none of the variability of the response data approximately its mean. The highest value of R-squared indicates that the model explains all the variability of the response data approximately its mean. The higher the R-value, the better overall a better fit in the model (*R-Squared*, 2021).

Analysis of variance (ANOVA):

Analysis of variance (ANOVA) is an analysis tool used to analyze the statistical models and its associated estimation procedures to test equality among several means by comparing variation among groups relative to variance within the group. ANOVA test was used to determine the impact of the independent variables on the dependent variable in the regression study. ANOVA was used for three or more groups of data to gain information about the relationship between the variables. If no true variation between the groups, the ANOVA's F-ratio is equally close to 1. The Fundamental Analysis-of-Variance equation for a regression model:

$$SS_T = SS_R + SS_E \quad (3.4)$$

Where the total sum of squares ( SST), the portion un-explained (SSE ), and the model sum of squares (SSR) (*Analysis of Variance (ANOVA)*, 2020).

-Statistical Hypothesis:

Statistical hypothesis the statements about relation. Hypothesis based on testing for the observed data determines if the probability is true for the provided hypothesis or not (Mahesh, 2021). (Stephanie, 2021) presented the null hypothesis as  $H_0$  and the alternative hypothesis is the opposite of the null or it is what is the test in hypothesis testing, denoted by  $H_1$  or  $H_a$ .

Testing significance of regression:

$$H_0: \beta_1 = \beta_2 = \dots = \beta_k$$

$$H_1: \text{at least one } \beta_i \neq 0$$

The hypotheses are related to the importance of regression. The rejection of  $H_0$  failed which implies that there is no relationship between the variables. Otherwise, if  $H_0$  is rejected, it implies that at least one  $\beta_i$  tells about an important relationship.

F-test:

An F-test is a test in statistics, which tests based on the F- distribution under the null hypothesis. It is used in comparing models that fitted to a set of data, to identify the model that best fits the population from which the data were sampled. In this study, the test was used to test the significance of the model (Sureiman, 2020).

To test  $H_0$  calculate the F-ratio, the ratio of group variances to the within-group variance. By calculating the overall mean of the group and dividing the sum by the number of groups, which is determined by rejecting or accepting the null hypothesis. If the ratio is equal to 1 then the null hypothesis is true but if it  $> 1$  there are differences between the population of means (Holmes et al., 2015).

Test on Individual Regression Coefficients (*t*-Test):

The t-test is used to check the significance of individual regression coefficients in the multiple linear regression model. It requires three values; the difference between the mean values from each data set, the standard deviation, and the number of data values of

every group as discussed (Kim, 2015). Adding an important variable to a regression model may make the model better. The hypothesis statements to check the coefficient  $\beta_j$ , are:

$$H_0: \beta_j = 0$$

$$H_1: \beta_j \neq 0$$

The test statistic for this test has the t-distribution:

$$T_0 = \frac{\text{mean} - \mu}{\text{standard dev.}/\sqrt{n}} \quad (3.5)$$

Where  $n$  is the sample size. The null hypothesis ( $H_0$ ) is zero. The alternate hypothesis ( $H_a$ ) the true difference is different from zero. This test measures the contribution of a variable while some other variables are included in the model (*An Introduction to T-Tests*, 2020).

P-value:

P-value is the predicted probability of rejecting the null hypothesis ( $H_0$ ) of a study question when that hypothesis is true (*P Values (Calculated Probability) and Hypothesis Testing - StatsDirect*, 2019).

Variance Inflation Factor:

VIF measures the combined effect of the dependencies among the regressors on the variance of the term for each term in the model (PAUL, 2006). (Kumar, 2020) stated that the practical experience indicates that if any of the VIFs exceeds 5 or 10, this indicates that the coefficients of associated regression are poor estimation due to multicollinearity.

### -Model Selection:

Stepwise Regression Methods were presented in (Cohen, 1991) as an approach to selecting a subset of effects for a regression model, by adding or pruning regressors one at a time. There are three categories of these methods:

1.) Forward Selection: This method begins with the assumption that there is no regressor in the model other than the intercept. Repeating the process until the results are optimal by inserting regressors into the model one at a time (Stephanie, 2017).

2.) Backward Elimination First, the procedure begins with a set of independent variables. Then compute F-ratio or T- value for each regressor. If the regressor with the smallest partial F or t value is less than the preselected F value, that regressor is removed from the model. Repeat a model by removing one at a time (Mao, 2004).

3.) Stepwise Regression: It is a mix of forwarding and backward methods. The principle is based on allowing the moves by adding or dropping variables at each step. The technique performs two steps involving forwarding selection and a backward step. Then, perform another forward step and another backward step. The process is continued until no action can be taken in either direction (Henderson & Denison, 1989).

### Residuals:

(Elsayir, 2019) discussed the residual expression as the difference between the observed value of the dependent variable ( $y$ ) and the mean value that the model predicts for that observation ( $\hat{y}$ ) is called the residual ( $e$ ). A residual is a vertical space between a data point and the regression line. Each data point has one residual.

$$\text{Residual} = \text{Observed value} - \text{Predicted value} \quad (3.6)$$

$$e = y - \hat{y} \quad (3.7)$$

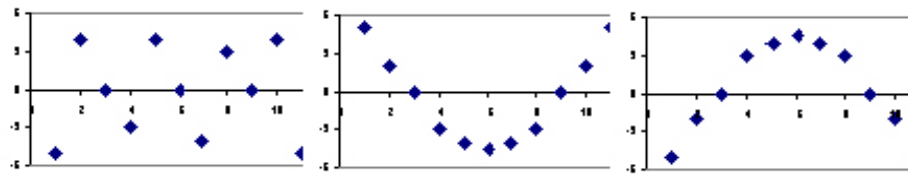
Both the sum and the mean of the residuals are equal to zero. That is,  $\sum e = 0$  and

$$e = 0 \text{ (Residual Analysis in Regression, 2015).}$$

### Residual Diagnostics:

A residual plot is a graph that presents the residuals on the vertical axis and determines the independent variable on the horizontal axis. If the points in a residual plot are dispersed randomly approximately the horizontal axis, the linear regression model is appropriate for the data, if not then a non-linear model is more appropriate (Aydin, 2014).

The residual plots three typical patterns as the following:



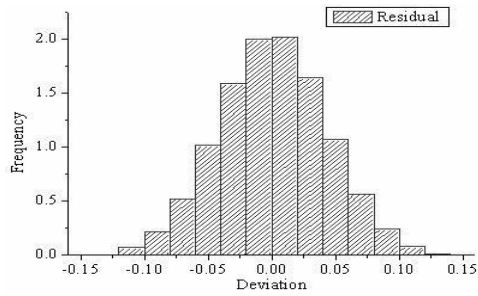
**Figure 3.2:** Random pattern, Non-random: U, Non-random: Inverted-U(*Residual Analysis*, 2020)

Figure 3.2 in the first plot shows a random pattern (no pattern shown), this indicates a useful fit for a linear model. The other plot patterns are non-random, shaped as U or inverted U.

### Checking normality:

#### -Histogram:

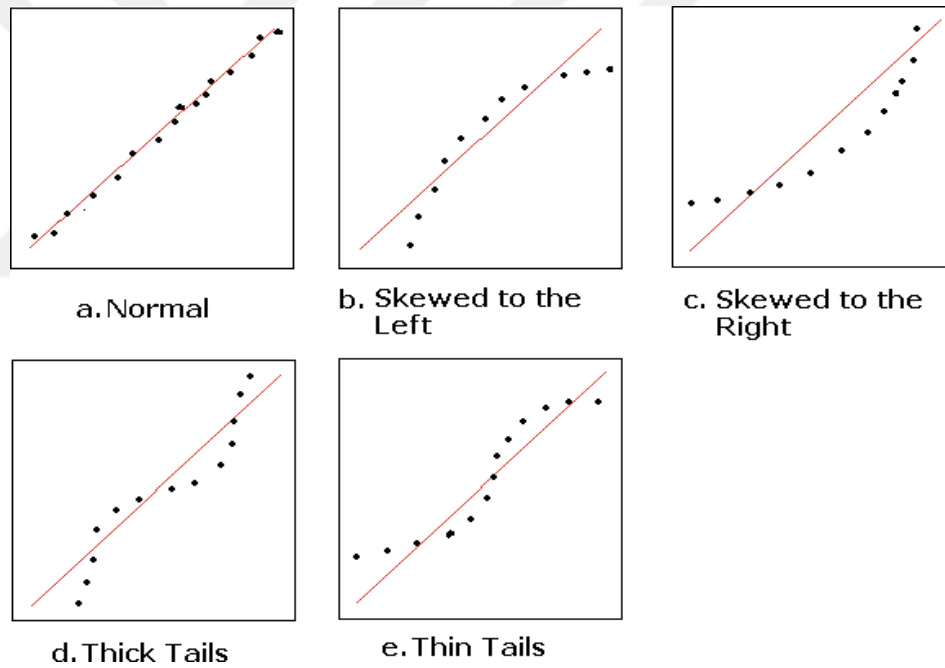
The Histogram of the Residual can be used to check whether the variance is normally distributed. A symmetric histogram is presented in the following Figure 3.3, distributed at approximately zero, which indicates that the normality assumption is likely to be true. The typical bell curve presents as the optimal indication as to normality (Owusu-Sekyere et al., 2013). When this cannot be gotten, the symmetrical histogram is sufficient.



**Figure 3.3:** Symmetric histogram

-Normality Plot:

The plots of normality are some of the ways that residuals can deviate from normality in the following Figure 3.4.



**Figure 3.4:** Normality plot (Royston, 1991)

### -Minitab

Minitab is the software used in this study. Minitab is a statistical program package designed for easy interactive use for quality improvement. Minitab is well appropriate for several applications in statistics, the software has an easy interface to use as a primary tool in analyzing studies data(Data Analysis, Statistical & Process Improvement Tools, 2021).

### -Operations Research

Operations research (OR) is a scientific method of problem-solving and decision-making of deterministic and probabilistic systems that is useful in the management of organizations or modeling real-life problems (*What Is Operations Research and Why Is It Important?*, 2019). In the analytical of operations research, applications are split into basic components and then solved in defined steps by software or mathematical analysis approach. The importance of operations research provides a more powerful method in decision-making than other software and analytics tools.

### - The Phases of Modeling

Operation Research is explained by (H.A. Eiselt & C.-L. Sandblom, 2007) and its stages of the modeling, the following steps are extracted from the book.

1-Identifying the problem and understanding the basic component.

2-Construct the objective function of the problem, determine the constraints if any, and decide the decision variables.

3-Use software or mathematical techniques to derive solutions to each component in the model construction.

4-Test the derived solution on the model, accept the objective and reject the unacceptable value.

5-Implement the solution with the new values in the actual problem.

Operation research or decision science employs to use in solving complex business or any problem through mathematical analysis (Singla, 2016). Operations analysis is based on building objective functions, and decision variables and restricting them with the constraints. An objective function is aimed to maximize the profit, efficiency, or maximize the expected return, it also aims to minimize the cost, time, or distance (Arsham, 1996). (Hausman, 1969) presented the decision variables are unknown quantity values that are expected to predict the output of the model, determined by the decision-maker. Constraints are the restrictions on the resources that are used in the model, money, energy, or materials. Also, constraints may be regulations from the government on geography or safety (S. & P., 2010).

#### -The Characteristics of OR

There are three characteristics of the operations research:

1-Optimization- The goal of operations research is to obtain the best performance within the constraints (Ba et al., 2016).

2-Simulation- This provides models and replications to try and test the solutions before implementing them (Lloyd G. Connelly & Aaron E. Bair, 2008).

3-Probability - This involves applying mathematical algorithms and specific data to unseal helpful insights and new risks (Abate & Whitt, 1992).

#### -Linear Programming

(Karthe, 2017) discussed Linear Programming as a method of decision science to obtain the optimization of problems to achieve the optimal solution, the best outcome may can the maximum profit or lowest cost in a numerical model with its conditions and constraints that are restricted with objective function by linear relationships equations. This type of programming does not contain powers such as  $X^3$  or  $X^5$ , also there are no division and multiplication operations between the variables (Kantorovich, 1998).

### -Application areas of Operation Research

The applications of the operation research method are wide,(Jain, 2016) discussed some examples as the following :

- Manufacturing
- Transportation
- Construction
- Financial departments
- Food
- Communication
- Military
- Solver

Solver is an add-in program in Microsoft Excel software, it can use for what-if analysis. It works with a group of cells in Excel that are used in computing the formulations. Solver sets the values in the cells of decision variables to satisfy the limitation on constraint cells and calculate the result for the objective cell. The platforms of the solver are the Simplex method which is used to solve linear programming models, GRG to solve nonlinear models and Evolutionary Solver uses a hybrid of genetic and classical optimization. Evolutionary Solver solves non-smooth problems (Thie & Keough, 2011).

### -Optimal Solution

Optimal solution definitions investigated by (Allahdadi & Mishmast Nehi, 2013) like the following:

- The values of the decision variables either maximize or minimize the objective function.

- A feasible solution at the point where the objective function reaches its maximum/minimum value.

- A solution that maximizes the discount-to-margins value function or that is most preferred.

- The specific decision variable values or values that provide the best output for the model.

Infeasible Solution can define in different words for the same meaning like no point satisfies all constraints of the problem, also there is at least one of the constraints that cannot be met. No feasible solution can be constructed (Mizuno, 1994) & (*When the Solver Fails - MATLAB & Simulink*, 2021).

- Unboundedness Solution

- A situation where the objective function is infinite (*Unbounded Solution - Quantitative Techniques: Theory and Problems [Book]*, 2019).

- Indicated when there are no positive values of replacement ratio (Konickova, 2006).

- Process of Linear Programming Example:

(*Steps to Solve a Linear Programming Problem / Superprof*, 2021) explained the procedure to analyze an example of linear programming for a linear system, the steps as the following:

Table 3.2. presents the information on a specific problem in real life is presented as follows :

**Table 3.2:** Linear programming model

| <b>Category1</b> | <b>Category2</b> | <b>Category3</b> | <b>Category4</b> |
|------------------|------------------|------------------|------------------|
| X1               | Z1               | P1               | L1               |
| X2               | Z2               | P2               | L2               |
| ....             | ....             | ....             | ....             |
| ....             | ....             | ....             | ....             |
| ....             | ....             | ....             | ....             |
| Xk               | ZK               | PK               | LK               |
| <b>Y1</b>        | <b>Y2</b>        | <b>Y3</b>        | <b>Y4</b>        |

This modeling aims to maximize Category 4 with the available constraints Y1, Y2, Y3, and Y4 using the above information.

1-Determine the decision variables:

Category1: The amount of category 1 required to obtain the optimal solution.

Category2: The amount of category 2 required to obtain the optimal solution.

Category3: The amount of category 3 required to obtain the optimal solution.

Category4: The amount of category 4 required to obtain the optimal solution.

2-The objective function is:

$$A=L1 * Category4 + L2 * Category4 + Lk * Category4$$

(Maximize Category4 in the best case)

3-Limit the categories with the constraints:

$$X1* Category1 + X2* Category1+ Xk* Category1 \leq Y1$$

$$Z1* Category2 + Z2* Category2+ Zk* Category2 \leq Y2$$

$$P1* Category3 + P2* Category3+ Pk* Category3 \leq Y3$$

$$L1* Category4 + L2* Category4+ Lk* Category4 \leq Y4$$

Using Excel, prepare a spreadsheet of data, and using the SUMPRODUCT function set the cell of the objective function to obtain the best solution. Assigning the cell for decision variables to obtain the solution by changing it. Using SUMPRODUCT function to build the cells of constraints. In Solver, choosing the objective to Max and determining the changing variables cells. Under constraints in the square, all constraints were added and selected the solve method to Simplex LP. By clicking solve the optimal solution will be present.

### -Sensitivity Analysis

This study is used to measure how the doubt in the output of a mathematical system can be divided and allocated to different sources of uncertainty in its inputs. Sensitivity analysis is used to increase the understanding of the relationships in the numerical model between input and output variables (Christopher Frey & Patil, 2002).

### -What-If Analysis

It is a tool in Excel that study a changing process for the values in cells to measure how those changes will impact the output of formulas on the worksheet. It consists of three kinds of analysis Scenarios, Goal Seek, and Data Tables (*Introduction to What-If Analysis*, 2021).

## 4. IMPLEMENTATION AND RESULTS

### 4.1. Internal Factors

#### 4.1.1. Strength Factors

Internal strengths are the factors that influence the cloud consumer. It provides a strategic competitive advantage to the cloud user in the pharmaceutical factories business to produce value and increase business efficiency by exploiting it.

##### *4.1.1.1. Strength from Political Side*

-Save the energy

The important concern that the cloud can solve is the consumption of power in information technology. By automatically turning on and off computers on demands, it provides efficient and intelligent use of the hardware resources, which led to reduced power consumption.

- Reduce the maintenance

The use of the cloud significantly reduces the number of devices that have to be maintained by the cloud consumer, and by utilizing the infrastructure of the cloud service from a cloud provider, the expert engineers of the provider operate and maintain the infrastructure and provide ongoing maintenance to the application stacks and operating system.

##### *4.1.1.2. Strength from the Economical Side*

-Low-cost maintenance

Cloud reduces the number of devices that have to be used and maintain by cloud consumer firms, using the services introduced by a provider and employing the infrastructure of the cloud led to low-cost maintenance of the software and hardware as it provides continuous maintenance.

-Reduce the cost of devices and software

While the cloud is a metaphor for a set of shared software and resources, the cloud consumer does not require to have its server and data storage. And there is no requirement to have some software that is accessible from a browser. And using a hybrid type of cloud services makes financial sense. The migration of applications and vary the usage by preserving the rest of on-premises or private cloud.

#### *4.1.1.3. Strength from Social Side*

-Support the old system

Cloud can support old software and hardware that is still used to preserve a company in work routine. Instead of replacing outdated services with modern capabilities and services.

- Friendly interface

The cloud service offered is approximately covered all requirements and the service provides 160+ tools at hand. The interface is very easy to use.

#### *4.1.1.4. Strength from Technical Side*

-Automatic update

Autosave files via cloud provider services are available if the user forgets to save the files or documents.

- Ideal use of resources

The appearance of existing files and previous research reduces the redundant files and enables optimal use of resources and better control over resources.

-Secure infrastructure

The protection of infrastructure is the most important feature of the cloud in the industry sector, enterprise requires significant infrastructure. It provides computer-based security, network protection, and identity security.

-Control the resources in disaster

Automatic work in the recovery and speed up to respond to the disaster to decrease the effects, by storing the critical data in different sites approximately the world in case of occurring a disaster.

#### *4.1.1.5. Strength from Environmental Side*

- Accessibility independent of time and location

The broad access to all information resources by clicking on the internet, it is enhancing the reach regardless of proprietary or locked stores of information and has the latest information from diverse locations in the world.

-Protect the environment

Decrease the waste of electronic resources to be efficient equipment and, on the other hand, reliable cloud centers on renewable energy.

#### *4.1.1.6. Strength from Legal Side*

- Acceptance in qualifications and accreditations

The expert engineers in consumers of the cloud have cloud provider certifications to validate technical knowledge and skills in the cloud. Also, the employees have regulated qualifications to meet quality standards.

#### **4.1.2. Weakness Factors**

Internal weaknesses are factors causing issues and concerns that directly affect the viability and progressiveness of the cloud consumer operational sector. Weaknesses are generally obstacles within the limitations within the relation between cloud provider and cloud consumer that can be directly addressed to improve the overall advantage.

##### *4.1.2.1. Weakness from Political Side*

-Increase the dependency

The workspace must provide more information such as group identification, artifact identification, information about the connected server that is hosting a particular component selected in the flow of the network, and the inbound or outbound server to map the technologies.

##### *4.1.2.2. Weakness from Economical Side*

-Limit cloud services

The limited control and downtime issues are in working in a cloud provider. The provider set default limitations on devices that change from city to city and restrict the users to the provider.

##### *4.1.2.3. Weakness from Social Side*

- Abuse market power

Increase the charging of unfair purchase or selling expenses or other illegal trading situations by direct or indirect controlling the market.

##### *4.1.2.4. Weakness from Technical Side*

Not defined.

##### *4.1.2.5. Weakness from Environmental Side*

-Require Internet connection

While the cloud-based on sharing resources over the internet, there is no access or storage without the internet.

#### *4.1.2.6. Weakness from Legal Side*

-Preserving privacy legal issues

Unauthorized sharing or using of important information about a sensitive case in the work and utilizing significant notes. The industry sector in the cloud may be exposed to pernicious attacks or stealing data to create profit.



## 4.2. External Factors

### 4.2.1. Opportunities Factors

Opportunities are external factors provided by a cloud provider that may be profitable for its consumer growth to capitalize on. The consumer can gain a competitive advantage by making use of these opportunities and exploiting it.

#### 4.2.1.1. *Opportunities from the Political Side*

-Adapt the change of the future

The innovative technology supports enhancing artificial intelligence and adapting to development platforms to raise the levels of life, it is like living a long decade in one year.

-Solve the problem

Cloud minimizes the requirement for costly on-site hardware and software, also eliminates storage infrastructure, it provides a high value of products with high-performance impact.

#### 4.2.2.2. *Opportunities from the Economical Side*

- Universal access to markets

The increased profit of cloud consumers can make new investment activities like opening new branches, also the firms can increase the production and safety stock to meet the requirement of international markets.

-Enhance the revenue through innovation

It is a main advantage of innovation is its contribution to increasing economic growth and to getting prestige among the industry producers.

#### *4.2.2.3. Opportunities from Social Side*

-Increase partnership with business organization

The combining of power of two huge companies can push ahead to obtain great science to research bold scientific ideas that affect multi-side in the two companies in its businesses as the first-class issue.

#### *4.2.2.4. Opportunities from Technical Side*

-Universal access

It enables the optimum productivity of crossing the files and getting access to all the other devices at different points in the world.

-Scalability

It enables to increase or decrease the resources on-demand and on request to meet the requirement of an operational process. It is a primary feature in the cloud.

#### *4.2.2.5. Opportunities from Environmental Side*

-Pay per use licenses

Model of payment that is based on pay for what cloud consumer uses the service of provider hybrid cloud to access high-value content, rather than buy it.

-High technology work environment

High technology environment provides different benefits that can improve the technology cloud consumer environment. It improves the spirited industry sector that is established on speeding the development of products, and also, increases the profits in a stable economic position.

#### *4.2.2.6. Opportunities from Legal Side*

- Legal regulation

The tenants and providers of cloud relationships are compliant with global laws and it imposed responsibilities on the back of cloud provider that is governed by cloud law to introduce services to the cloud consumers.



#### **4.2.2. Threats Factors**

The external environment conditions from the cloud provider's side that affect and arise the risk of the reliability and profitability of the consumer business and operational concerns. Although the threats from the external side are uncontrollable, cloud consumer firms can take some efforts to reduce its impact.

##### *4.2.2.1. Threats from the Political Side*

###### - Security issues

The main concern of the cloud freaks out from the security concern; lack of visibility, the external share of the data, and incomplete control over the system.

###### - Incumbents effects

Incumbents may lead to rising risk-taking in the cloud. They can use the market of cloud and the brand to confuse, negatively affecting the business and interrupting the operational process.

##### *4.2.2.2. Threats from the Economical Side*

###### - Large hidden costs

The amount of backup cost is hidden and not defined, pricing is based on the amount of storage space and amount of restored data in the firm backup data.

##### *4.2.2.3. Threats from Social Side*

###### -Cultural invasion

The cloud change and replaces the way of interaction between the employees, based on decreasing the communication between each other and replacing it to deal with devices and high-level platforms. It would replace the traditional operation and reshape the environment of work.

#### *4.2.2.4. Threats from Technical Side*

##### *-Data security*

Despite the cloud provider built on the highest standards of privacy and data safety as the most secure universal infrastructure of cloud by encrypting or managing retention of the data. The protection of the data is determined as the top threat of using the cloud in global smart firms.

##### *- Incompatibility*

The capacity of the cloud provider and cloud consumer systems to be compatible in the software applications like the formatting in the same version as word processors in the two systems then they can open the documents.

#### *4.2.2.5. Threats from Environmental Side*

##### *-Changing cloud provider*

The difficulty of migration from one provider to another in the cloud introduces many challenges. Financial concerns are effect the redesign of the application architecture, and the training of users for the new cloud system. Numerous transformations and disruptions with notable different systems and processes.

#### *4.2.2.6. Threats from Legal Side*

##### *-Lack of standard regulation*

The regulation of cloud suffers from a lack of transparency, and specific criteria set in the usage under industry in the global smart factories.

**Table 4.1:** The SWOT/PESTEL analysis conclusion

| <b>Features</b>      | <b>Strengths</b>   | <b>Weakness</b>                   | <b>Opportunities</b>   | <b>Threats</b>                            |
|----------------------|--|-----------------------------------|--|---|
| <b>Political</b>     | -Save the energy.<br>-Reduce the maintenance.  | -Increase the dependency.         | -Adapt to the change of the future.<br>-Solve the problem.   | -Security issues.<br>-Incumbents effects. |
| <b>Economical</b>    | -Low-cost maintenance.<br>-Reduce the cost of devices and software.  | -Limit cloud services.            | -Universal access to markets.<br>-Enhance the revenue.       | -Large hidden costs.                      |
| <b>Social</b>        | -Support the old system.<br>-Friendly interface.   | -Abuse market power.              | -Increase partnership with business organizations.           | -Cultural invasion.                       |
| <b>Technical</b>     | -Automatic update.<br>-Ideal use of resources.<br>-Secure infrastructure.<br>-Control the resources in a disaster. | -Not defined.                     | -Universal access.<br>-Scalability.                          | -Data security.<br>-Incompatibility.      |
| <b>Environmental</b> | -Accessibility independent of time and location.<br>-Protect the environment.                                      | -Require Internet connection.     | -Pay per use licenses.<br>-High technology work environment. | -Changing cloud provider.                 |
| <b>Legal</b>         | -Acceptance qualifications and accreditation.  | -Preserving privacy legal issues. | -Legal regulation.   | -Lack of standard regulation.             |

The relation between the cloud provider and cloud consumer presented in Table 4.1. above, even though there are some disadvantages but it deserves to use due to its benefits sides and good impact.

### **4.3. Linear Regression**

In this section, the study investigates the relationship between the total profit and the main revenues of cloud consumer firms using AI equipment and tries to estimate the economic pattern between the variables. This research tries to create a relation by ML by using Minitab software in a way the data mining itself builds a relation. Then linear programming is applied to optimize a dependent variable limit to a set of independent variables in a linear relationship, within linear constraints of independent variables. Simplex algorithm was used in this study because this method can help to optimize linear programming problems for any number of decision variables. Also, an Excel solver was selected for accuracy purposes.

The models are created based on the premier smart factory for pharma products data that is available under the official website of the firm and linear analysis methods, using the firm's revenues and total profits for quarter 4 of the 2020 year till to the third quarter of 2021. All data for this study were derived directly from the quarterly reports of cloud-AI based factory.

The data includes the main factors of the company, which are Total profit, Vaccine's revenue, Oncology revenue, Internal Medicine revenue, Hospital revenue, Inflammation & Immunology revenue, and Income for Rare Disease. The revenues values involve the United States and the international.

When each multiple regression model is generated, R-squared, P-value, VIF, and the residuals are analyzed. When a simple regression model is created, R-squared value, P-value, and residuals are observed. Stepwise regression methods are used in the model selection process, which is presented in the following model selection section.

-Model Selection: Forward Selection Method:

Regression Analysis: Total Revenue versus Vaccines, Oncology, Internal Medicine, Hospital, Inflammation & Immunology, Rare Disease

$\alpha$  to enter =0.05

### Regression Equation

Total Revenue = 9753 + 0.9876 Vaccines

### Coefficients

| Term     | Coef   | SE Coef | T-Value | P-Value | VIF  |
|----------|--------|---------|---------|---------|------|
| Constant | 9753   | 145     | 67.17   | 0.009   |      |
| Vaccines | 0.9876 | 0.0145  | 68.24   | 0.009   | 1.00 |

### Model Summary

| S       | R-sq   | R-sq(adj) | R-sq(pred) |
|---------|--------|-----------|------------|
| 129.241 | 99.98% | 99.96%    | 99.69%     |

### Analysis of Variance

| Source     | DF | Adj SS   | Adj MS   | F-Value | P-Value |
|------------|----|----------|----------|---------|---------|
| Regression | 1  | 77776509 | 77776509 | 4656.39 | 0.009   |
| Vaccines   | 1  | 77776509 | 77776509 | 4656.39 | 0.009   |
| Error      | 1  | 16703    | 16703    |         |         |
| Total      | 2  | 77793213 |          |         |         |

**Figure 4.1:** Forward selection results for a company data

The output of Figure 4.1. presents there is a relation between the Total Revenue equation and Vaccine revenue, it also presents T-value equals 68.24 which tells about good relation. P-value tells about significant relation. The output of R-squared indicates that 99.98% of the variation of Total Revenue is explained by the predictor value .

## 2.) Backward Elimination:

The Total Revenue is perfectly explained by all of the variables combined, so the standard error is zero. The test of statistics is undefined when regressing Total Revenue with the six main factors on linear regression (as demonstrated in APPENDIX A).



-Regression Analysis: Total Revenue versus Vaccines, Oncology, Internal Medicine, Hospital, Inflammation & Immunology, Rare Disease

$\alpha$  to remove =0.05

### Regression Equation

$$\text{Total Revenue} = 4137 + 0.9774 \text{ Vaccines} + 1.849 \text{ Oncology}$$

### Coefficients

| Term     | Coef   | SE Coef | T-Value | P-Value | VIF  |
|----------|--------|---------|---------|---------|------|
| Constant | 4137   | *       | *       | *       |      |
| Vaccines | 0.9774 | *       | *       | *       | 1.50 |
| Oncology | 1.849  | *       | *       | *       | 1.50 |

### Model Summary

| S | R-sq    | R-sq(adj) | R-sq(pred) |
|---|---------|-----------|------------|
| * | 100.00% | *         | *          |

### Analysis of Variance

| Source     | DF | Adj SS   | Adj MS   | F-Value | P-Value |
|------------|----|----------|----------|---------|---------|
| Regression | 2  | 77793213 | 38896606 | *       | *       |
| Vaccines   | 1  | 50846603 | 50846603 | *       | *       |
| Oncology   | 1  | 16703    | 16703    | *       | *       |
| Error      | 0  | 0        | *        |         |         |
| Total      | 2  | 77793213 |          |         |         |

**Figure 4.2:** Backward selection results for a company data

Figure 4.2. presented starred for some values ,the reason for the starred values is the significant value has eliminated at  $\alpha=0.05$  and therefore it will not report the significance. VIF it is very good value , the lower the VIFs value the better, which indicates the complete absence of collinearity. Also, the value of R-squared is totally explained by the predictors of Vaccines and Oncology.

### 3.) Stepwise Selection:

Regression Analysis: Total Revenue versus Vaccines, Oncology, Internal Medicine, Hospital, Inflammation & Immunology, Rare Disease.

$\alpha$  to remove =0.05 and  $\alpha$  to enter =0.05

#### Regression Equation

Total Revenue = 9753 + 0.9876 Vaccines

#### Coefficients

| Term     | Coef   | SE Coef | T-Value | P-Value | VIF  |
|----------|--------|---------|---------|---------|------|
| Constant | 9753   | 145     | 67.17   | 0.009   |      |
| Vaccines | 0.9876 | 0.0145  | 68.24   | 0.009   | 1.00 |

#### Model Summary

| S       | R-sq   | R-sq(adj) | R-sq(pred) |
|---------|--------|-----------|------------|
| 129.241 | 99.98% | 99.96%    | 99.69%     |

#### Analysis of Variance

| Source     | DF | Adj SS   | Adj MS   | F-Value | P-Value |
|------------|----|----------|----------|---------|---------|
| Regression | 1  | 77776509 | 77776509 | 4656.39 | 0.009   |
| Vaccines   | 1  | 77776509 | 77776509 | 4656.39 | 0.009   |
| Error      | 1  | 16703    | 16703    |         |         |
| Total      | 2  | 77793213 |          |         |         |

**Figure 4.3:** Stepwise selection results for a company data

Stepwise selection output presented by Figure 4.3., the better value of VIF equals 1. R-squared presents a good relation where 99.98% of Total Revenue presented by Vaccine. P-value equals 0.009, the null hypothesis can be rejected.

## -Simple Linear Regression: Total Revenue versus Vaccines

### Regression Equation

$$\text{Total Revenue} = 9750.7 + 0.98770 \text{ Vaccines}$$

### Coefficients

| Term     | Coef    | SE Coef | T-Value | P-Value | VIF  |
|----------|---------|---------|---------|---------|------|
| Constant | 9750.7  | 86.9    | 112.16  | 0.000   |      |
| Vaccines | 0.98770 | 0.00963 | 102.55  | 0.000   | 1.00 |

### Model Summary

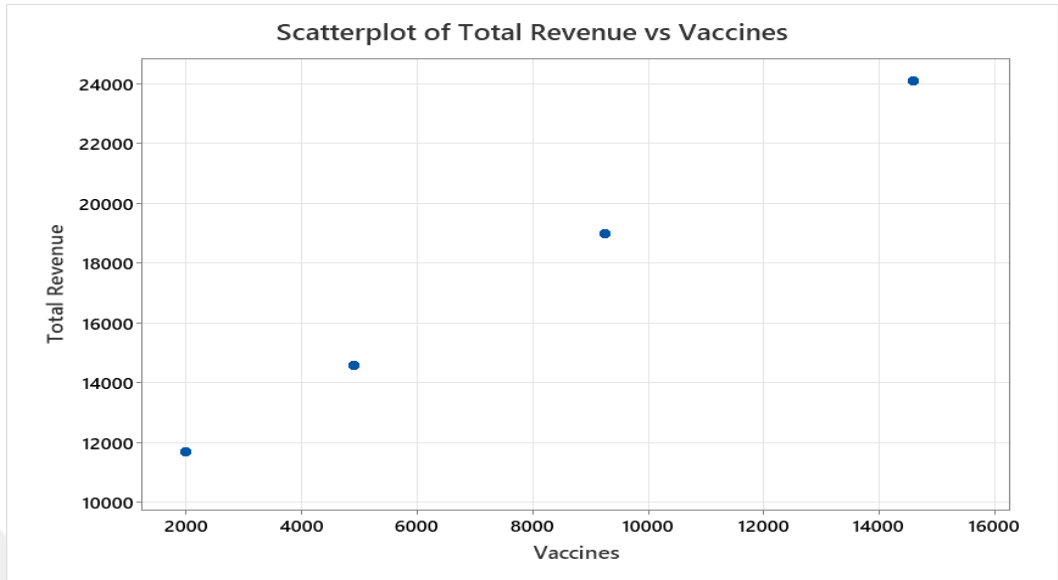
| S       | R-sq   | R-sq(adj) | R-sq(pred) |
|---------|--------|-----------|------------|
| 91.4128 | 99.98% | 99.97%    | 99.88%     |

### Analysis of Variance

| Source     | DF | Adj SS   | Adj MS   | F-Value  | P-Value |
|------------|----|----------|----------|----------|---------|
| Regression | 1  | 87876340 | 87876340 | 10516.17 | 0.000   |
| Vaccines   | 1  | 87876340 | 87876340 | 10516.17 | 0.000   |
| Error      | 2  | 16713    | 8356     |          |         |
| Total      | 3  | 87893053 |          |          |         |

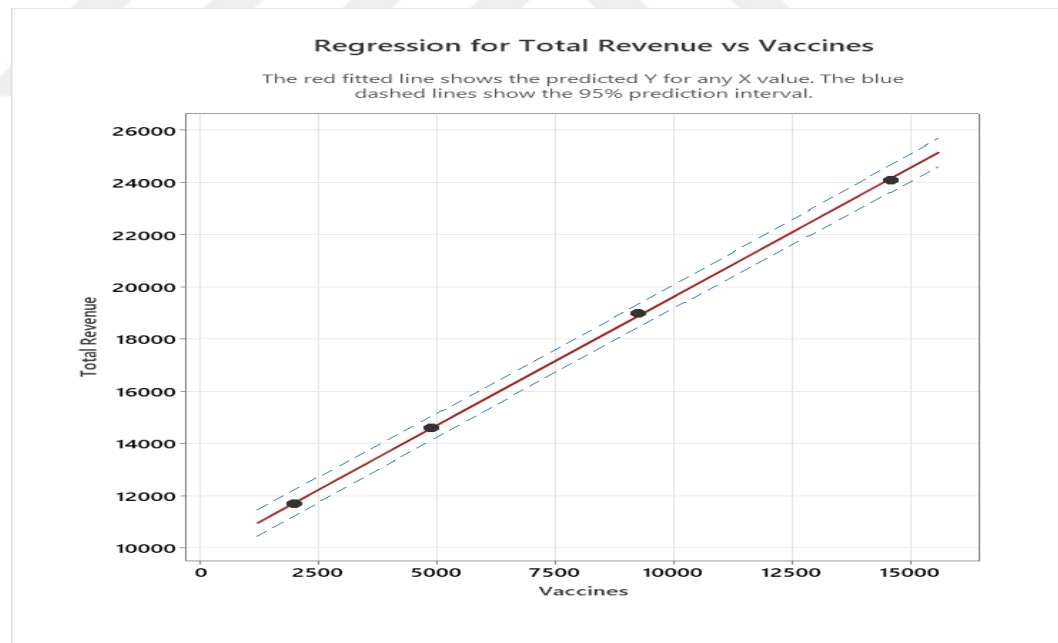
**Figure 4.4:** Simple Linear Regression results for Total Revenue versus Vaccines

Figure 4.4. presents the output of Simple linear regression between the value of Total Revenue versus Vaccines. T-value equals to 102.55 , the greater the confidence we have in the coefficient as a predictor. P-value is zero, the smallest value of a that results in the rejection of H0. VIF equals 1 ,it seems good estimation.



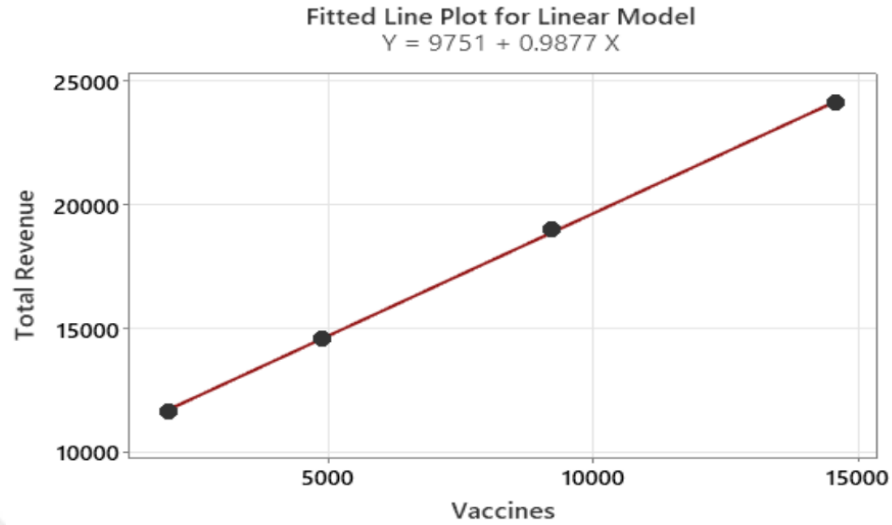
**Figure 4.5:** Scatterplot for Total Revenue versus Vaccines

Figure 4.5. presents positive relationship between the tested variables.



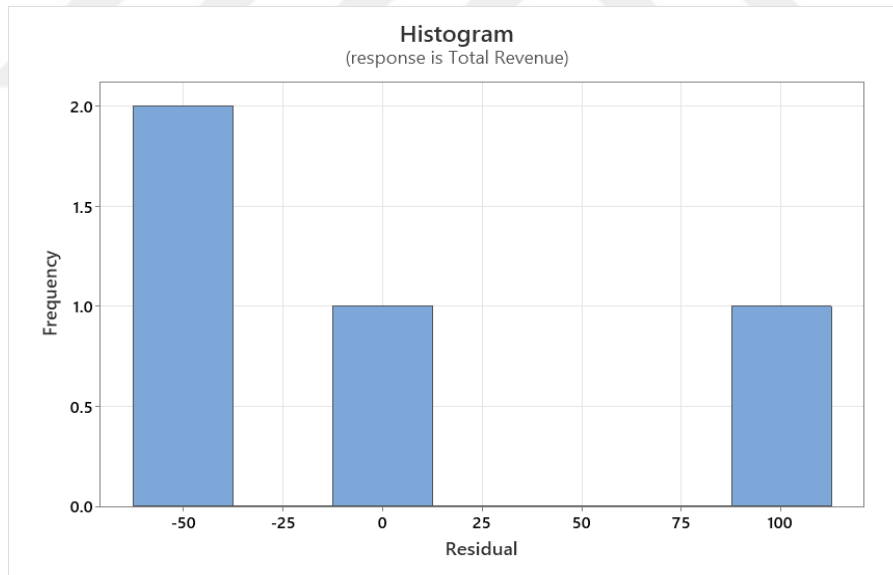
**Figure 4.6:** Regression for Total Revenue versus Vaccines

Figure 4.6. presents the best represents the data in the Scatterplot between the dependent and independent variables.



**Figure 4.7:** Fitted Line plot for Total Revenue versus Vaccines

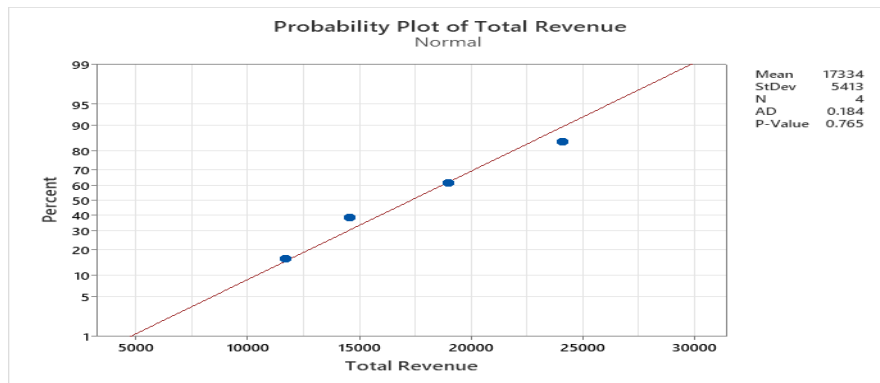
Figure 4.7. presents the relationship between one continuous predictor as a Vaccine in the model and its response.



**Figure 4.8:** Histogram chart

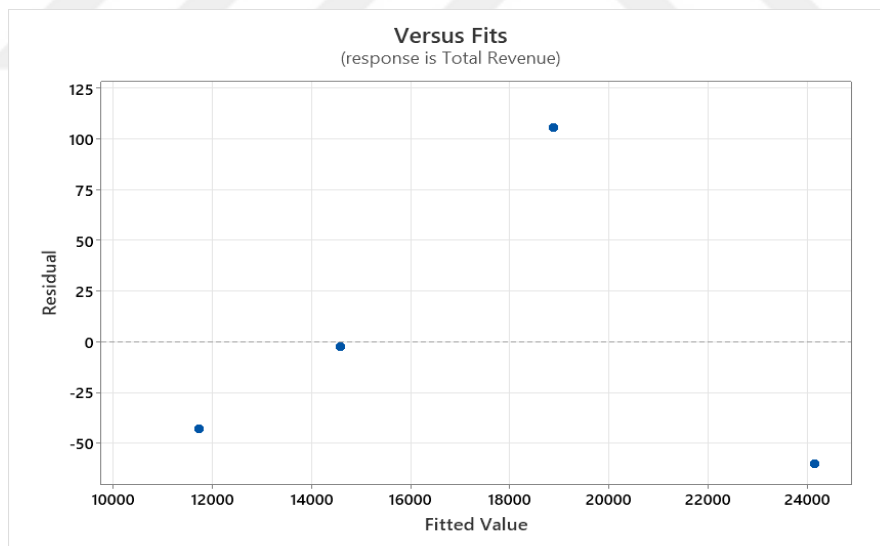
Histogram chart presents by Figure 4.8. appears to be not symmetric. It is actually rejected because there are not many data points, which creates a gap in the Total Revenue.

## Normality Test:



**Figure 4.9:** Anderson-Darling test

Figure 4.9. presents Anderson-Darling test is also examined. It indicates the smaller measure of the deviations (AD) between the fitted line, the better the fit, and the data points approximately follow a straight line so it seems the normal distribution is a good fit.



**Figure 4.10:** Residual versus Fitted value

Also, the residual plot in the Figure 4.10. demonstrates no pattern, which implies that this model indicates the independence of the residuals, and the linear regression analysis is appropriate for the data.

- Analysis of the Results:

The hypothesis in this case is:

$H_0: \beta_1 = 0$  (The relationship between Total Revenue and Vaccine is not significant).

$H_1: \beta_1 \neq 0$  (The relationship between Total Revenue and Vaccine is significant).

According to the findings of the final model Simple Linear model (Total Revenue versus Vaccines), it can be seen that the great T value, the evidence against the null hypothesis, also the p-value from the Analysis of Variance table is zero. The null hypothesis can be rejected, which means there is a significant relationship between Total Revenue and Vaccine revenues at any significant level. From the Model Summary table, the R-squared value is 99.98%, which indicates that 99.98% of the variation of Total Revenue is explained by the model.

Also, examining Figure 4.9 the normality plot could seem to indicate deviation from normality. Besides, the residual plot above demonstrates no pattern. Despite this, it must be considered that the x-axis depicts data on a much smaller scale than the actual data and the number of the data points examined totals only six.

Considering these factors, the normality assumption seems to be satisfied. The normality test, Anderson-Darling, is also examined. However, the normality test was rejected and similarly, the histogram appears to be not symmetric. It is also actually rejected because there are not many data points, which creates a gap in the Total Revenue.

Usually, to test normality, the sample size should be large. Even though according to the normality test, the normality assumption is not satisfied. The model satisfies the goal of finding the pattern and trend of the company's Total Revenue and checking if the Vaccine factor plays a statistically significant role in the Total Revenue. Based on the study findings, after the model selection method is processed, the significant category is the vaccine, presented in the forward, backward, and stepwise methods. The consensus demonstrates that revenue from Vaccine plays a statistically significant role in the Total revenue of the company.

Therefore, the equation that can best depict the firm Total Revenue is:

$$\text{Total Revenue} = 9750.7 + 0.98770 \text{ Vaccine} \quad (4.1)$$

From the model and study, it can be concluded that revenue from Vaccines plays the most significant role in the firm's Total Revenue value. It can be used as a tool to estimate the company's future total revenue. The following analysis formulates a proposal linear programming model that would suggest a model that will maximize the overall vaccine revenue to ensure optimum profit for the firm.

- Proposal model:

Proposal linear programming model that will maximize the overall vaccine revenue. The company manufactures different types of vaccines like the C vaccine, P vaccine, and T vaccine, using a common ingredients inventory of Preservatives, Acidity stabilizers, Adjuvants, Antibiotics, Cold holders, etc. The firm makes a profit for each unit of the vaccines C vaccine \$23, P vaccine \$10, and T vaccine \$7.

Ingredients are limited to one operational process and in this study, there is a proposed model to determine the most profitable mix of vaccines to manufacture.

The required units are listed in Table 4.2 for each vaccine, and the inventory or safety stock of the ingredients to use in the manufacturing is as the following:

- The inventory for Preservatives is 940
- The inventory for Acidity stabilizers is 400
- The inventory of Adjuvants is 800
- The inventory for Antibiotics is 1000
- The inventory for Cold holders is 600

**Table 4.2:** The usage units of each ingredient

| <b>Type of Ingredient</b> | <b>C vaccine</b> | <b>P vaccine</b> | <b>T vaccine</b> |
|---------------------------|------------------|------------------|------------------|
| Preservatives             | 1                | 1                | 1                |
| Acidity stabilizers       | 1                | 2                | 3                |
| Adjuvants                 | 2                | 1                | 1                |
| Antibiotics               | 1                | 1                | 2                |
| Cold holder               | 2                | 1                | 1                |

-The decision variables used in the model are as the following:

C vaccine: the number of products from the C vaccine that can the firm prepare in this operational process.

P vaccine: the number of products from the P vaccine that can the firm prepare in this operational process.

T vaccine: the number of products from the T vaccine that can the firm prepare in this operational process.

-The objective function is to maximize the overall profit from vaccine manufacturing as the following equation:

$$Z = 23 * C \text{ vaccine} + 10 * P \text{ vaccine} + 7 * T \text{ vaccine}$$

-The constraints to limit the common ingredients in the process of manufacturing to the inventory:

$$1 * C \text{ vaccine} + 1 * P \text{ vaccine} + 1 * T \text{ vaccine} \leq 940 \text{ (inventory of Preservatives)}$$

$$1 * C \text{ vaccine} + 2 * P \text{ vaccine} + 3 * T \text{ vaccine} \leq 400 \text{ (inventory of Stabilizers)}$$

$$2 * C \text{ vaccine} + 1 * P \text{ vaccine} + 1 * T \text{ vaccine} \leq 800 \text{ (inventory of Adjuvants)}$$

$$1 * C \text{ vaccine} + 1 * P \text{ vaccine} + 2 * T \text{ vaccine} \leq 1000 \text{ (inventory of Antibiotics)}$$

$$2 * C \text{ vaccine} + 1 * P \text{ vaccine} + 1 * T \text{ vaccine} \leq 600 \text{ (inventory of Cold holder)}$$

The analysis by solver presented the maximum total amount of profit that can the firm obtain from this operational process or Z is equal to \$6900, also the analysis determines the most profitable mix of products to build is 300 units of C vaccine, zero unit of P vaccine and zero units of T vaccine to achieve the maximum revenues in this process.

The following Table 4.3 demonstrates the number of units from each one of the ingredients to manufacture 300 units of C vaccine:

**Table 4.3:** The numbers of units used in the proposed model

| Type of Ingredient  | Inventory | The used | C vaccine | P vaccine | T vaccine |
|---------------------|-----------|----------|-----------|-----------|-----------|
| Preservatives       | 940       | 300      | 1         | 1         | 1         |
| Acidity stabilizers | 400       | 300      | 1         | 2         | 3         |
| Adjuvants           | 800       | 600      | 2         | 1         | 1         |
| Antibiotics         | 1000      | 300      | 1         | 1         | 2         |
| Cold holder         | 600       | 600      | 2         | 1         | 1         |

Provided the former results, there is a positive economic influence of cloud computing, it created a new source for revenues in way of increasing profit.

Using sensitivity analysis as a mathematical model, in this context, this study describes the reality of our estimates by changing the price and approximating how the profit changes by decreasing and increasing the units of the most profitable produced vaccine. The following Table 4.4 describes the profit, units produced and its price. The maximum revenues indicate \$10000 if the price increase to \$25 and the units produced are 400.

**Table 4.4:**The number of units and the profit after the price changed from (What if analysis)

| <b>The number of units produced by the vaccine</b> |        |      |      |      |      |       |
|--|--------|------|------|------|------|-------|
| <b>The price of vaccine per unit</b>               | \$6900 | 200  | 250  | 300  | 350  | 400   |
|  | \$21   | 4200 | 5250 | 6300 | 7350 | 8400  |
|  | \$22   | 4400 | 5500 | 6600 | 7700 | 8800  |
|  | \$23   | 4600 | 5750 | 6900 | 8050 | 9200  |
|  | \$24   | 4800 | 6000 | 7200 | 8400 | 9600  |
|  | \$25   | 5000 | 6250 | 7500 | 8750 | 10000 |

## **5. CONCLUSION**

### **5.1. Chapter Outline**

This first section navigates the conclusions sections of this study. The second section outlines the research. The third section presents the conclusions of this study. Section 5.4 and 5.5. respectively discussed the practical and managerial analysis. Then the limitation presented for the study in section 5.6.

### **5.2. Research Overview**

The pharmaceutical factory case study was chosen as a leader in the research's context of the smart factories. This study investigates the relationship between artificial intelligence and cloud computing under the primary question of the study: Does cloud computing impact artificial intelligence in the management of a medical smart factory?

Furthermore, the study assessed the four aspects of one of the most important factories in the world of the business as a cloud consumer in its relationship with the cloud provider. The research also examined the external and internal factors beneficial to this case study.

After reading former literature, a theoretical and practical framework developed, and it proposed a model that describes the construct and its indicators within the study area. The research questions examine the study objectives area with four secondary questions as follows:

1-What are the unique competitive advantages of a medical smart factory using the cloud?

2-What are the possible issues of using the cloud from a cloud provider on the artificial intelligence machines in a medical smart factory?

3-Is there any relation between cloud and artificial intelligence in the economy of a medical smart factory?

4-Is there a specific part of the gross profit affecting the total company's revenue since using the cloud?

This study was built on the main hypothesis that was based on former reports related to this topic where it supposes that the using cloud-based AI machines have a possible positive effect on the management of a medical smart factory.

This study comprises two sides; the first part used SWOT/PESTEL analysis investigated the external and internal beneficial features of the case study factory, the threats, and the opportunities within the context of the work between the factory and the provider of the cloud. This part aimed to get the objectives of the first and second hypotheses of this research, the first one is to study the first secondary hypothesis derived to investigate that cloud usage builds new opportunities and strengthens its advantages in medical smart factories that examine the research question number 1. The second secondary hypothesis study that the use of the cloud creates issues and concerns for consumers and this hypothesis examines the research question number 2. The study demonstrates the theory of the first and second hypotheses and it presented there is a notable positive impact of using cloud technology in the smart factory based on AI equipment that related to increasing the productivity and developing the efficiency in the work. It also suggests the possible issues that may be facing the firm based on the cloud service that arise the risk of the reliability and the profitability of the consumer of the cloud.

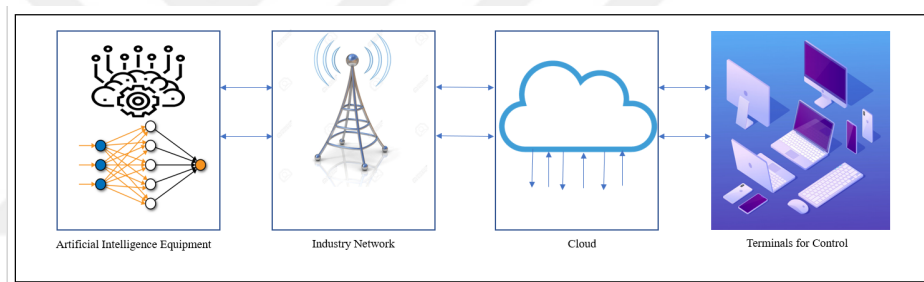
The second chapter investigates the third secondary hypothesis that supposes that cloud computing has an impact on developing the growth of a medical smart factory and examines the third and fourth of the research questions listed above. In this context, the study is based on getting the aim of the hypotheses to test which of the revenues has directly related to the Total Profit value. The revenues of the main factors of company, are Vaccine revenue, Oncology revenue, Internal Medicine revenue, Hospital revenue, Inflammation & Immunology revenue, and Income for Rare Disease. The model search for an equation that determines which revenue plays a key role in the firm's Total Revenue value. Besides the proposed analysis presenting the maximum total amount of profit that can the firm obtain within limited inventory in a specific operational process, also the analysis determines the most profitable mix of products to build maximum profits and achieve the maximum revenues in the process. Data tested, validated, and analyzed using Minitab software and Excel tools. The analysis demonstrates a correlation between the Total revenue and Vaccine revenue

value for the specified period in the study as the equation that can best depict the firm Total Revenue:

$$\text{Total Revenue} = 9750.7 + 0.98770 \text{ Vaccine}$$

The analysis identifies Vaccine revenue as a key role factor that can develop the economic growth rate which answered the fourth question of the research that asking is there a specific part of the gross profit affects the total company's revenue since using the cloud.

The findings of the study are consistent with the economic reports issued by the economic researchers and it supported the hypotheses investigated in this research as in Figure 5.1 below.



**Figure 5.1:** Hypothesis model variables

### **5.3. Conclusion**

The study found that there is a positive relationship between cloud computing usage and artificial intelligence in factory management.

Using cloud service and artificial intelligence reflecting on a smart factory in generated more opportunities and be aware of the possible threats. Also, it may help to exploit the internal strength and decrease the effect of the factory's weakness.

In addition, there is a possible equation built on the amount of the current and previous revenue of the case study firm that presents an increase in the total profit with direct sales of the vaccines developed by the firm each quarter.

The study of data for this relationship results in ensuring a beneficial relationship between cloud and artificial intelligence as stated by (Burla, 2022). This validates former literature for (Habibi et al. ,2014). Increasing the performance and the reliability of the artificial intelligence industries impacts developing the level of growth in the economy, and lifestyle.

To obtain this research examines the relationship between cloud computing, artificial intelligence, and factory management; the research generated some hypotheses to check the purposed model, as demonstrated in Figure 5.1, Hypothesis model variables.

Hypothesis model variables were studied by SWOT/PESTEL analysis and Linear Regression analysis. The researcher in this section presents the analysis results from a medical smart factory point of view. With the decrease of cloud cost, and increase in the level of equipment for artificial intelligence in the medical sector in specific, the requirement arises to review how the cloud and reach the benefit of it to utilize in manufacturing.

To have a bright look at this case, this study investigated one of the greatest manufacturing businesses in the world of pharma industries of vaccines development as the major achievement of this context to discover the relationships between the proposed frameworks.

AI is acknowledged as one of the principal strategic aims for smart factory management, which as research outcomes presented, is highly impacted by cloud utilization.

Results and outcomes of research presented a great impact of the cloud on increasing the performance and saving time, besides decreasing the cost of the storage of cold data in medical smart factories.

#### **5.4. Theoretical and Practical Implications**

This study provides a deep view of the circumstances that affect the management of the case study, cloud, and artificial intelligence. The literature review recently combined with the partial relationships of the proposed model framework. This research suggested a model that checks relations between components at the same time.

The conceptual structure of the study generated by the purposed model in this research was implemented in a pharmaceutical firm within the context, to provide an in-depth sight of the relation between cloud, artificial intelligence, and factory management. This type of study was developed by a researcher who explores the modern top titles of the world which applied in the medical products firm and within the pharma industry sector taking a service of cloud as a case study.

Recently, cloud services become increasingly popular, and more companies joined the service in the world with the specific goal of increasing economic growth and reducing costs. Hence the necessity to promote a theoretical and practical framework that firms can obtain advantage from when building cloud-based business and implementing a full smart factory plan. This research plan attended to provide a depth sight into the circumstances that the factory team considers precious factors that surround the firm.

### **5.5. Managerial Implications**

There are multiple implications provided by this research that enable the managers in the engineering management team to obtain benefits.

The first point is to have a solid strategy that tries to implement a factory with a full covered cloud service and be aware of the weakness and threats that can cause a problem or threaten the firm. On the other hand, it exploited the internal strength of the factory and the external opportunities as a chance to develop the economic relation and growth of its business within the same field with the partners in the workspace.

Based on the previous note, the managers choose carefully the type of cloud they are using in their company to develop the operational equipment that is connected continuously through the networks of its factory to enhance the work process and protect it from future issues. Cloud can donate important advantages if it reaches the computing power required to build artificial intelligence industries.

Second, the outcomes present the value of the cloud in developing the levels of revenues of using it, therefore a necessity to improve the strategies and programs that increase the usage of cloud service in factories and obtain a high profit from its use. Inside smart factories, this led to increasing the production, and development of new industries, and these results reflected in progressing the total profits. i.e., extra in the revenues and profits. The managers should monitor and control the cloud service to evaluate the effects of its use on the tools and hardware devices to reach the optimal process of development.

## **5.6. Limitations**

Despite the scientific results of this research, like other human works, it faced some limitations and obstacles.

First of all, this analysis studied only within the smart factory for medical products firms as pharma industry sector, which requires to be extended into other industries and other sectors type.

Second, the structure of the study did not include other determinants that influence both artificial intelligence and smart factory sides. Even though it found a meaningful relation between all the purposed variables in the framework, but different variables could be conducted to the model.

The important limitation was the lack of cost information of implementing smart factories cloud-based and the specific revenues of each sector that are influenced by cloud in the factory as power supply amount and decrease the cost of purchasing new equipment required by the factory.

## **6. RECOMMENDATIONS**

### **6.1. Chapter Outline**

The first chapter navigates the recommendations part of this research. Section 6.2. presents the recommendations based on the research results. The last chapter introduces the future recommendation for this study.

### **6.2. Recommendations**

The study of data for the relationship results for this study in ensuring a beneficial relationship between cloud and artificial intelligence and this wants more awareness for the cloud service to build strong relationships with artificial intelligence equipment to enhance novel manufacturing and increase the performance of the artificial intelligence industries. Which influences on developing the relationship value of community and this is reflected in providing value and developing the level of the human life.

These results require a study from the firm's managers to construct strategies within the cloud plan development to build business management cloud-based, then earnestly strive to obtain benefit from its benefits. Besides that, the cloud providers implement warranty deeds to adequate protection for companies that use the cloud from threats.

### **6.3. Future Research**

The next time research in the same context may expand in the framework for other sectors and different products in the world. It also can extend to diverse factors that affect the workspace. For the sectors, it could be expanded to cover studying the learning organizations in government, which may be the information of implementing it published in the local newspaper.

From the factors side, it suggested studying more influencer factors that affect artificial intelligence with cloud in the firm as the same methodology of study or in a different method.

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## APPENDIX A

The following Table Appendix A presents the raw data used in the analysis of this research, the quarters from Q42020 till to Q32021 , the study period for the six main products revenues.

| Quarter | Vaccines | Oncology | Internal Medicine | Hospital | Inflammation & Immunology | Rare Disease |
|---------|----------|----------|-------------------|----------|---------------------------|--------------|
| Q42020  | 2,001    | 3,024    | 2,308             | 2,220    | 1,267                     | 865          |
| Q12021  | 4,894    | 2,862    | 2,594             | 2,343    | 1,065                     | 824          |
| Q22021  | 9,234    | 3,145    | 2,403             | 2,259    | 1,041                     | 895          |
| Q32021  | 14,583   | 3,085    | 2,097             | 2,367    | 1,094                     | 869          |

**Table Appendix A:** The revenues (*in billion U.S. dollars*) from the six main products of the

case study

## APPENDIX B

The following Figure Appendix B presents analysis of Multiple Regression: Total Revenue versus Vaccines, Oncology, Internal Medicine, Hospital, Inflammation & Immunology, Rare Disease. The best VIF value presented by Vaccine where it is the best predictor and strong relation with Total Revenue.

### Regression Equation

Total Revenue = 6633 + 0.9912 Vaccines + 0.6512 Oncology + 0.4758 Internal Medicine

### Coefficients

| Term              | Coef   | SE Coef | T-Value | P-Value | VIF  |
|-------------------|--------|---------|---------|---------|------|
| Constant          | 6633   | *       | *       | *       |      |
| Vaccines          | 0.9912 | *       | *       | *       | 1.70 |
| Oncology          | 0.6512 | *       | *       | *       | 1.79 |
| Internal Medicine | 0.4758 | *       | *       | *       | 2.09 |

### Model Summary

| S | R-sq    | R-sq(adj) | R-sq(pred) |
|---|---------|-----------|------------|
| * | 100.00% | *         | *          |

### Analysis of Variance

| Source            | DF | Adj SS   | Adj MS   | F-Value | P-Value |
|-------------------|----|----------|----------|---------|---------|
| Regression        | 3  | 87893053 | 29297684 | *       | *       |
| Vaccines          | 1  | 51910156 | 51910156 | *       | *       |
| Oncology          | 1  | 10541    | 10541    | *       | *       |
| Internal Medicine | 1  | 13870    | 13870    | *       | *       |
| Error             | 0  | 0        | *        |         |         |
| Total             | 3  | 87893053 |          |         |         |

**Figure Appendix B: Multiple Regression**