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Organizational digital technologies adoption process and its impact on business models - a case study

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Abstract (Ita)

Nel corso della storia umana, le rivoluzioni industriali sono state la principale forza motrice per migliorare continuamente i metodi di produzione. Il concetto di "Industria 4.0" proposto dalla Germania rappresenta che la società umana è entrata nella quarta rivoluzione industriale. Ogni paese si sforza di afferrare la nuova ondata di rivoluzione industriale e applica le tecnologie digitali per perseguire uno sviluppo guidato dall'innovazione.

Questa tesi esamina come le aziende manifatturiere hanno adottato le tecnologie digitali, quali sono le loro capacità di implementazione e come le tecnologie digitali hanno cambiato i modelli di business delle aziende. La tesi utilizza il metodo empirico, intervistando due aziende manifatturiere in Italia.

La prima parte di questo documento è il background e le domande di ricerca. Poi esamina il quadro teorico su cosa sono le tecnologie digitali e le teorie dei modelli di business. Sulla base delle teorie, ha progettato un questionario che è stato utilizzato nell'intervista. La terza parte è il quadro metodologico. Le ultime due parti sono i risultati chiave e la conclusione.

Abstract (En)

Throughout human history, industrial revolutions have been the main driving force to continuously improve production methods. The concept of “Industry 4.0” proposed by Germany represents that the human society has stepped into the fourth industrial revolution. Every country strives to grasp the new wave of industrial revolution and applies digital technologies to pursue innovation-driven development.

This thesis looks at how did manufacturing companies adopt the digital technologies, what are their implementation capacity, and how digital technologies have changed the companies business models. The thesis uses the empirical method, interviewed two manufacturing companies in Italy.

The first part of this paper is the background and the research questions. Then it looks at the theoretical framework on what are digital technologies and the theories of business models. Based on the theories, it designed a questionnaire that has been used in the interview. The third part is the methodology framework. The last two parts are the key findings and the conclusion.

Chapter 1. Introduction

1.1 Background

The ever-changing technology innovation has increased the market environment competition fiercely which urges companies to strengthen their core competences. The fourth industrial revolution (Industry 4.0) is realizing the digital transformation for manufacturing and production and related industries on value creation process. However, the adoption of these digital technologies may pose challenges for many organizations, especially for those traditional manufacturing companies. Questions have been frequently asked like: What does digitalization mean for manufacturing? How it impacts on organizational management? How companies should respond to the changing industrial environment? This paper will look at these questions and look for the answers.

1.2 Research aim

The aim of this research is to look at the adoption situation of manufacturing firms on digital technologies, as well as how digital technologies impact the organization business models.

1.3 Research questions

The thesis will conduct a multiple case study method. By using the technology adoption models, the thesis will ask the manufacturing company, among the 9

digital technologies defined in industry 4.0, which technologies have been adopted and which are not. It will also ask how much percent it has been implemented. Then, this thesis will ask the question how did the business models have been affected before and after the adoption of these technologies.

1.4Research design and structure

By answering the above research questions, first this thesis presents the theoretical framework of definition of digital technologies, theories and models of technology innovation adoption models, and the theories of organization business models. Then, based on the foundation of the theoretical framework, the questionnaire of the interview has been designed, which are attached in the end of the thesis. Finally, it presents the empirical findings and the conclusion.

Chapter 2. Theoretical Framework

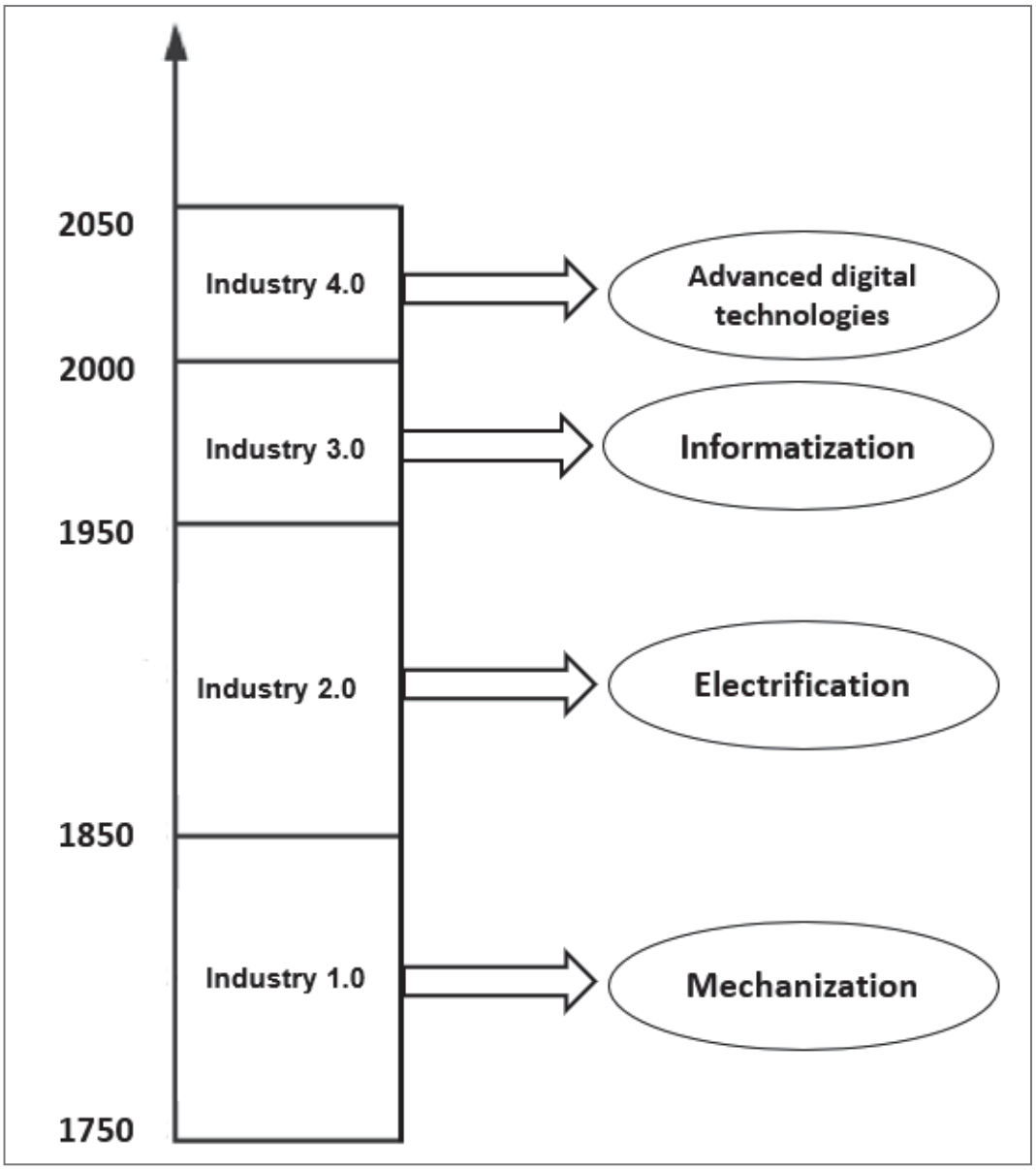
2.1 The development of the digital technologies

2.1.1 Presence of Industrial 4.0

Since the first industrial revolution invented by the steam engine, human society has experienced three industrial revolutions. The division of the four industrial revolutions is based on the source of power. The industrial revolution is divided into four main phases according to the main symbols: steam power, internal

combustion mobility, electric power and intelligence interconnection. Each revolution has greatly improved labor efficiency.

Figure 1. Industry 4.0 development timeline



The first industrial revolution refers to the technological revolution initiated in Britain in the 18th century. It was a huge revolution in the history of technological development. It opened the era of replacing manual labor with machines. This is not only a technological reform, but also a profound social change. The first industrial revolution started with the birth of working machines with steam engines to generate the power. The first industrial revolution allowed the factory system to replace manual workshops, and allowed machines to replace manual labor.

The second was the industrial revolution of internal combustion engines and electric power. In the second industrial revolution, internal combustion engines and electrical engineering were invented and were combined effectively together. Steam power is gradually being replaced by electricity, and electricity has begun to be widely used in many industries. During the working process in the first industrial revolution, workers move but objects did not move. In the second industrial revolution, objects began to move while people were fixed in positions. For example, the birth of the assembly line where workers stay in fixed position to complete a single production task. After this, the human society has achieved electrification. The production of parts and the assembly of finished products have been separated which leads to the large-scale industrial production.

The third industrial revolution began in the late 1900s. It was characterized by the use of electronic products and computers, and the invention of the Internet to realize the spread of automation and digitization.

After entering 2010, the use of Internet extended more to the industrial field, which realize the further integration of the Internet and industry. The concept of "Industry 4.0" was firstly proposed at Germany Hannover Messe in 2013. Then Germany established "Industry 4.0" platform to conduct specific research and implementations. It has been upgraded to the national strategic level. Since then this concept has also been widely spread to many other countries, industries, and enterprises and Germany is regarded as the leader of the fourth industrial revolution. “Securing the future of German manufacturing industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0” made a detailed statement on the concept of Industry 4.0, that is:

“Industry 4.0 will involve the technical integration of CPS into manufacturing and logistics and the use of the Internet of Things and Services in industrial processes. This will have implications for value creation, business models, downstream services and work organization.”

In essence, the core of Industry 4.0 is to integrate physical and virtual systems, establish a cyber-physical system (CPS), build a smart factory, and intelligentize the production process to achieve the transformation and upgrading of traditional manufacturing to smart manufacturing.

2.2 An overview of digital technologies

2.2.1 Internet of Things

• Defining Internet of Things (IoT)

There has been various of definitions for Internet of Things (IoT) from different perspectives. Samuel Greengard defines IoT as "'things' or 'objects' that connect to the Internet—and each other" (2015, p.14). Klaus Schwab describes IoT as a bridge between the digital and physical applications, through which people are able to connect technologies with various platforms (2016).

Some scholars believe that when describing the use of IoT technology, the term IoT system is more accurate because the system is designed purpose-specifically for one or a set of applications. The system usually consists sensors or actuators so that the system can process signals and time-series data (Serpanos and Wolf, 2018). In summary, IoT can be understood as the network of physical objects attached or embedded with sensors, software and other technologies so that data can be collected and exchanged through the internet.

• Applications of IoT:

1) IoT Medical Devices (IoT-MD)

The IoT medical devices are applications using IoT based platform to improve the quality and efficiency on health care management. This includes remote health

management, sport and fitness with wearable IoT devices, chronic diseases and care for the elderly etc.

2) Smart Home

IoT based platform can remotely monitor and manage home resources. For example, Ninja Block is a platform consisting of huge range of add-on sensors which are able to track home appliances. People will know from phone if there is a gas pipe leak, or even serve as burglar alarm while no one is at home.

3) Smart City

Smart cities improve infrastructure, public utilities and services through collecting and analyzing data from IoT devices thereby improving citizens' life quality. For example, London launched a smart parking project which is a system that pairs a network of sensors enabling customers to get updated parking information.

4) Industrial IoT (IIoT) and Smart Agriculture

Industrial IoT (IIoT) means that to use the IoT technology under an industrial setting (Boyes et al., 2018). One application of IIoT is to implement sensors in machines to detect if the components surpassed their designed thresholds. In the same way, Smart Agriculture can be understood as to use the IoT technology in agriculture setting.

5) Smart Environment and Disaster Management

IoT system can send out alerts to communities before a catastrophe occurs.

2.2.2 Cloud computing

When personal computers were invented, data and programs were mostly located in local resources. Cloud computing is a big shift from the traditional way and becomes one of the most significant technologies which may reshape the information technology (IT) market and process. It has advantages including cost savings, high availability, and easy scalability.

• Defining Cloud Computing

Armbrust et al. (2010) defined cloud computing as "both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services" (2010, p51). Another definition of cloud computing is "the hardware, systems software, and applications delivered as services over the Internet" (Antonopoulos and Gillam, 2010, p3).

The above-mentioned definitions indicate that cloud computing is network service through a set of internet applications provided by computing infrastructures.

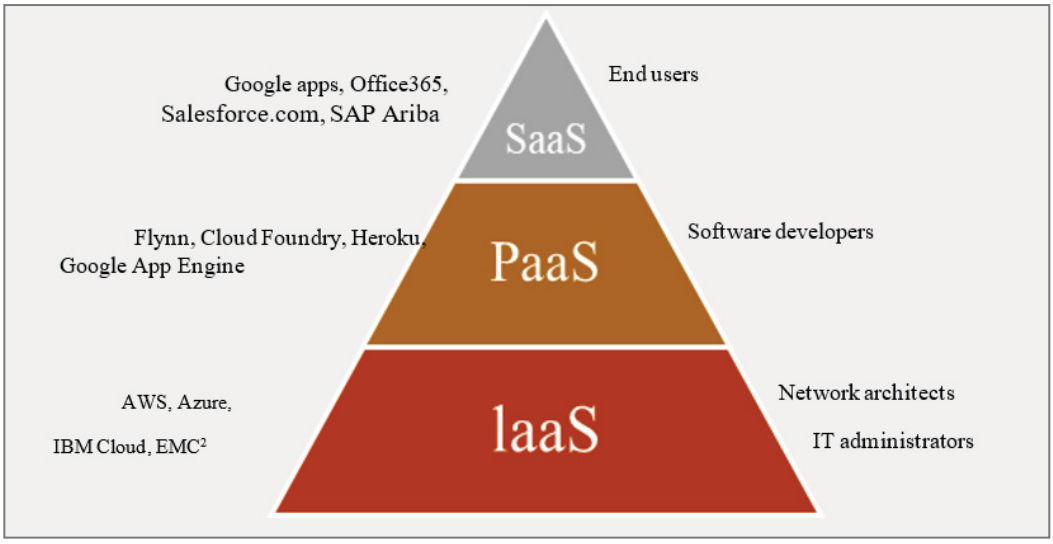
With the cloud computing technology, users can use various of devices such as computers, tablets, and smartphones to access programs, storage, and application-development platforms through internet via services offered by cloud computing providers.

• Cloud Computing Application

Currently there are three main types of cloud-based delivery models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

SaaS is a service provided by a company to its users in the form of applications or software. Users access applications through the internet but they do not control the operating system, hardware or network infrastructure. The second model is PaaS. PaaS provider provides a platform where users can build their applications. PaaS users control the applications but do not control the operating system, hardware or network infrastructure that they are using. The third mode is IaaS which allows users to buy hardware, storage devices and other network infrastructures. Users can control the infrastructures and develop the operating systems and applications. Figure 2 below gives examples for these three models.

Figure 2.SaaS, PaaS and IaaS as 3 main cloud-based delivery models and examples



2.2.3 Big Data

In the era of information, as more and more data has been generated, processing large amounts of data within acceptable time and resources has become a major

challenge for traditional tools. In order to extract value from these data more effectively, organizations need to find new tools and methods specifically for big data processing.

- Defining Big Data

One of the most cited definition of Big Data is from a report of Meta group (now acquired by Gartner) in 2011 even though the article did not mention the term of "Big Data" directly. It first came up with the idea of "3Vs" characteristics for big data, which is Volume, Velocity, and Variety. Volume means the amount of data. The rapid development of E-commerce generated the depth and the width of the data available in a transaction online. E-commerce companies can provide its goods or services to more individuals and the quantity of data that can be collected has increased hugely. Velocity refers to the speed with which data are being generated.

Big data is high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation

2.2.4 Virtual and Augmented reality

The concept of VR was proposed in the 1960s, and the first commercial VR tool appeared in the late 1980s. The study of VR was initiated in the computer graphics field and has been extended to several disciplines. Nowadays, a number of

companies have invested hugely on VR and AR, such as Sony, HTC, Google and Samsung etc.

- Defining Virtual and Augmented reality

The earliest known VR system or application can be traced to 1950s. Morton Heilig invented a machine device called “Sensorama” which is an immersive simulator allowing people watching a 3D film along with audio, vibrations, smells and wind. In 1965, Ivan Sutherland came up with the idea of the Ultimate Display:

“The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming, such a display could literally be the Wonderland into which Alice walked” (Sutherland, 1965).

Figure 3. Sensorama

This concept has been seen as the fundamental blueprint for VR. Since then several definitions have been developed. For example, Jonathan Steuer (1992) wrote “A Virtual Reality is defined as a real or simulated environment in which a perceiver experiences telepresence”. Fuchs and Bishop (1992) described VR is a technology that allows users to immerse and manipulate in the virtual world where there are real-time interactive graphics and 3D models, combined with display technologies. These definitions highlight 3 common characteristics of VR: immersion, presence, and interactivity (Mütterlein, 2018; Cipresso et al., 2018).

AR is a variation from VR. AR can be defined as a technological system in which virtual objects are added to the real world in real-time during the user’s experience. VR aimed at immersing the user entirely into a computer-generated virtual world,

while AR took the opposite approach, in which virtual computer generated objects were added to the real physical world (Wellner et al., 1993).

• Applications of Virtual and Augmented reality

The devices used in the virtual environment play an important role in creating a successful virtual experience. Here are some applications in these areas:

1) Retail, AR is growing at an increasing rate and the reach of AR applications will double due to the high penetration of AR-enabled devices (e.g., cell phones and tablets). Amazon was one of the first brands to introduce AR technology, using it to allow consumers to "try on" clothes online, providing unprecedented convenience for online shoppers.

2) Architecture, in the field of architecture, augmented reality allows architects, builders, developers and clients to see the building in three dimensions and the interior design at any stage of construction, visualizing the entire building. In addition to this, AR technology can help identify errors and problems in the job.

3) Tourism, with the help of augmented reality, travel brands can provide potential visitors with an immersive experience. With AR solutions, agents and destinations can provide visitors with more information and wayfinding directions. AR apps can help vacationers navigate resorts and learn about destinations.

4) Education, augmented reality can help educators get students to use dynamic 3D models in the classroom to help them understand the knowledge and stimulate learning in a fun way. Students will benefit from AR's visualization capabilities.

Healthcare, AR can provide 3D digital images and key information for surgeons to implement. This allows surgeons to access important information needed during surgery without having to be far from the surgical area.

2.2.5 Additive manufacturing

• Defining Additive manufacturing

Additive manufacturing (AM) is also known as 3D-printing (3DP). The 3DP technologies allow to manufacture parts or products layer by layer, directly from digital product data (Savolainen and Collan, 2020). The first working 3D printer was created by Charles Hull in 1984. The 3D printer works in a way similar to the traditional inkjet printer, but instead of printing 2D inks on paper, 3D printer uses materials to build a three-dimensional object layer by layer (Berman, 2012). This process is always aided by a computer-aided design (CAD) to translate the design into the movement by the machine.

Though AM will not replace the traditional method, it is expected to penetrate into many niche areas. Comparing with the traditional manufacturing methods, the 3D printing has 5 key advantages: cost, speed, quality, innovation/transformation, and impact (Attaran, 2017). 3D printing will make it possible to let retailors design and

customize goods without delivery time, which saves cost on shipping and inventory. It also has the advantage on prototyping, spare parts production, and unique items customization.

• Additive manufacturing applications

With the improvement of technology, the breadth and influence of AM continue to expand, making it a feasible method for various industries. Bogue divided the AM applications into two main categories: rapid prototyping and component manufacturing (2013). Here are some industries that are benefit from the AM applications (Attaran, 2017). The first is aerospace industry. NASA has been testing additive manufacturing in zero gravity, hoping to establish on-demand manufacturing for astronauts. This will allow the parts used to maintain and repair the International Space Station to be produced in space. The second industry is automotive industry which is one of the earliest industries to apply AM technologies. For over 20 years, General Motors has been using additive manufacturing to produce prototypes to speed up time-to-market and to reduce product development cost. The medical industry has found a revolutionary way to implement AM. Manufacturing custom implants such as hearing aids and prostheses is one of the first ways AM has changed the medical industry. For the architectural industry, the computer simulation software and wood models have always been used to review designs. The application of AM allows complex details

and precisions on a small scale thus it is more effective to simulate and improve the design.

2.2.6 Cybersecurity

• Defining Cybersecurity

The term “cybersecurity” has been used broadly and its definition is highly variable. Before giving the definition of cybersecurity, it is necessary to deconstruct the term to understand what is “cyber”. According to the oxford dictionary, “cyber” relates to “electronic communication networks and virtual reality” (Oxford, 2021). Cyberspace is an information environment created by networks where people are connected together to exchange information (Craigen et al., 2014). Cyberspace is not static but rather a dynamic, evolving domain which is a “multilevel ecosystem of physical infrastructure, software, regulations and ideas” (Deibert and Rohozinski, 2010). As for the definition of cybersecurity, Amoroso described as “… involves reducing the risk of malicious attack to software, computers and networks. This includes tools used to detect break-ins, stop viruses, block malicious access, enforce authentication, enable encrypted communications, and on and on” (Amoroso, 2006). To enable the network realizing the resource sharing function, firstly it is necessary to ensure the network hardware and software operation, and then to make sure the safety of information exchange. However, the system security procedures might be vulnerable when exploited by the hackers, especially for

manufacturing companies who are more likely to be targeted by malicious attack due to the security reason is always not their priority (Lezzi et al., 2018).

2.2.7 Cyber-Physical Systems (CPS)

• Defining Cyber-Physical Systems (CPS)

It is generally believed that Cyber-Physical Systems (CPS) is the core technology for realizing the industrial Internet of Things. CPS is an integration of physical objects and software platforms to allow the exchange of information between different components (Kumar et al., 2019). CPS emphasizes the real-time and dynamic information feedback and cyclic process between the physical world and the information world. It deeply integrates various information technologies: sensors, embedded computing, cloud computing, network communication and software. It makes various informatization capabilities highly collaborative and autonomous, and hence to achieve that the production application system can monitor and change the characteristics of the physical world autonomously, intelligently, dynamically and systematically (Chen, 2017).

• Cyber-Physical Systems (CPS) application

CPS covers a wide range of applications: from tiny nano-robots to huge engineering infrastructure equipment, from urban traffic information to remote surgical medical systems, transportation, medical care, agriculture, energy, national defense, construction, and manufacturing all are involved.

2.2.8 Integrated systems

System Integration is a process commonly implemented in the fields of engineering and information technology. It involves the combination of various computing systems and software packages in order to create a larger system, and this is what drives Industry 4.0 to work at its optimum. System Integration increases value to a system by creating new functionalities through the combination of sub-systems and software applications.

2.2.9 Simulations

manufacturing environment. The digital tools, which achieve the design of the production system, have the ability of self-configuration; therefore, they enable effective shop-floor management. In increasingly competitive business environments, simulation offers the adjustments into complex systems by planning the operations, having the knowledge and information and accurate estimations about the system by using the engineering capacity (Weyer et al., 2016). The strategic planning could be done by simulation models which allows dynamic investigation for production systems by the help of real time data acquired. Therefore, the system creates real time optimization on operations (Uhlemann, 2017).

2.2.10 Autonomous robot

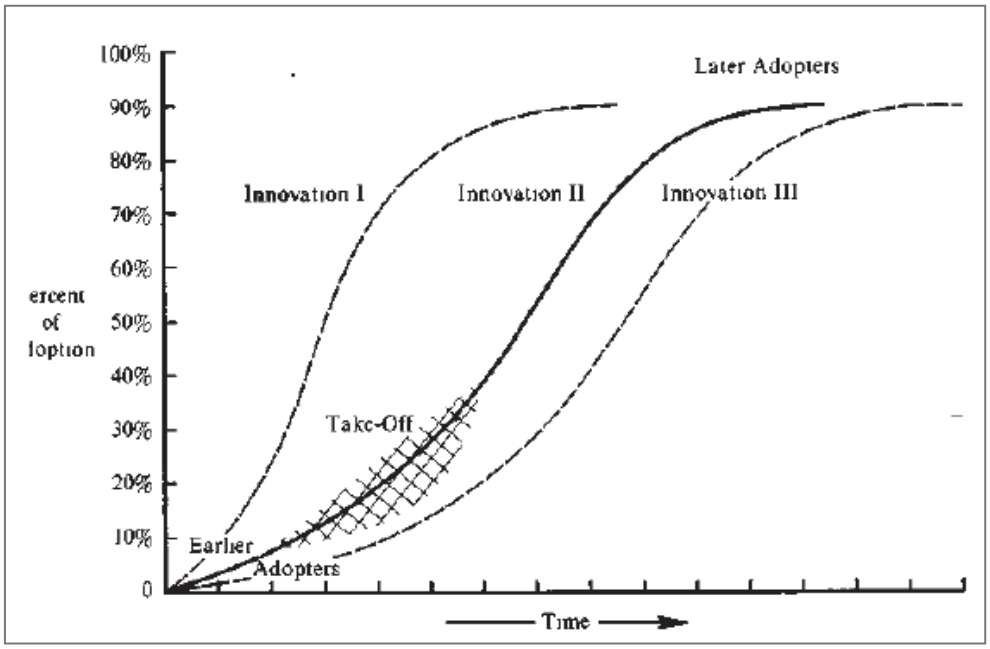
Robots are used in manufacturing industries in order to solve complex tasks which can not be solved easily by a human. By the traditional automation strategy, companies could not fully implement JIT strategies and continuous improvements if they do not opt for autonomous robots. The current improvements in industries would make use of robots less complicated and easily utilized them. Various human-robot interfaces create close cooperation of utilising robots and human brain. However, the operator usage is also significant since it enables in connection with the station on performed tasks. Therefore, the needed information would be provided by the operator and controls the system, giving instructions to the industrial robots (Hedelind and Jackson, 2011). The usage of more industrial robots in factories accelerates with Industry 4.0. Robots could be used in several areas such as production, logistics, distribution activities and could be controlled remotely by humans thanks to the human robot cooperation. Several new technologies are introduced by the companies in terms of robotics technology such as Kuka LBR IIWA is achieving sensitive tasks in working places and collaborate with human. This robot has the ability of learning from human colleagues and check, optimize and document the tasks by the help of cloud systems (Aiman et al., 2016).

2.3 Technology adoption models

2.3.1 Diffusion of Innovations (DOI)

Rogers (2003) introduced the innovation diffusion model in 1962. Due to further research and theoretical development, the model has been expanded and revised in the past 40 years. The framework was developed in many studies in this field. Rogers (2003, p. 5) defines diffusion as follows: “Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system”. Based on this definition, Rogers (2003) defines four elements of the diffusion process: innovation, communication channels, time and the social system.

Figure 4. Diffusion is the process by which (1)an innovation (2)is communicated through certain channels (3)over time (4)among the members of a social system



- **Innovation**

Innovation refers to new ideas or new practices that are regarded as new by the adopted unit. As far as human behavior is concerned, it does not matter whether an idea is "objectively" new or not. The individual's perception on the newness of the innovation determines his or her reaction to it. If this idea is new to the individual, then it is an innovation (Rogers, 2003). Rogers (2003, p. 15) explained the difference in innovation adoption rate through the characteristics of innovations:

Table 1. Adoption rate among innovation characteristics

Characteristics	Description	Adoption rate is high when	
Relative advantage	is the degree to which an innovation is perceived as better than the idea it supersedes	high	
Compatibility	is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters	high	
Complexity	is the degree to which an innovation is perceived as difficult to understand and use		low
Trialability	is the degree to which an innovation may be experimented with on a limited basis	high	
Observability	is the degree to which the results of an innovation are visible to others	high	

Generally speaking, receivers believe that innovations with greater relative advantages, compatibility, testability, observability, and lower complexity will be adopted faster than other innovations.

- **Communication Channels**

Communication channels are another important element of the diffusion process. Communication is the process by which participants create and share information with one another in order to reach a mutual understanding (Rogers, 2003). Diffusion

is a special type of communication in which the information exchanged is related to new ideas. The essence of the communication process is to exchange information which involves the following elements:

Table 2. Communication process

Process	Elements
1	An innovation
2	Individuals or other adopters who have the knowledge or experience of using innovations
3	Other individuals or other entities who do not yet understand the innovation
4	A communication channel connecting the two units

A communication channel is the means by which messages get from one individual to another. For example, mass media channels (radio, television, newspapers) are usually the fastest and most effective way to inform potential adopters of the existence of innovation. Another channel is interpersonal channels which involve face-to-face communication between two or more individuals (Rogers, 2003).

- **Time**

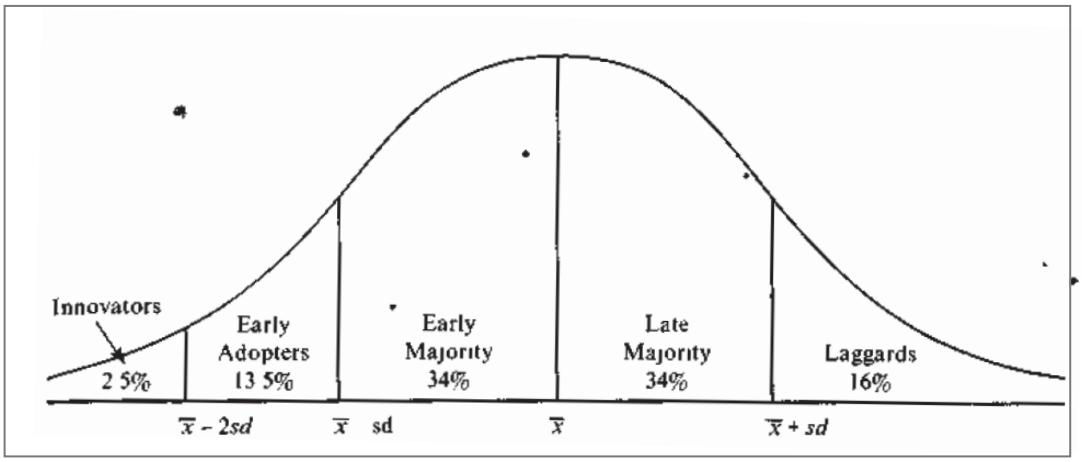
Time is the third element of the diffusion process, and it measures the innovation decision process in the following way:

(1) a person from the first knowledge of innovation to his adoption or rejection;

(2) compared with other members of the system, the relative earliness or lateness with which an innovation is adopted;

(3) in a given time period, the number of members who adopt the innovation in the system, that is, the adoption rate in a given period of time.

Figure 5. Adopter categorization on the basis of innovativeness



Rogers (2003, p. 280) defines five adopter categories measured by time: (1) innovators, (2) early adopters, (3) early majority, (4) later majority, (5) laggards. Figure 4 shows how adopters can be categorized based on their innovativeness.

The innovator is a pioneer who adopts "innovation" most quickly. Early adopters often have the characteristics of opinion leaders, and their prudent characteristics and leadership skills have a decisive influence on subsequent adopters. Therefore, they have a profound impact on the promotion of "innovation". The work enthusiasm, interpersonal relationship and influence of early adopters make them the best candidate to serve as a "reform agent" or "reform promoter" in an organization. The early majority accepted "innovation" after careful consideration. The late majority (late majority) is a group of suspicions, and gradually accepted as

adopters after the doubts about "innovation" have been eliminated. Laggards (laggards) are traditional and conservative people who have to adopt "innovation" as a last resort.

- **The social system**

The social system is defined as a set of interconnected units that participate in solving problems to achieve a common goal. The members or units of the social system can be individuals, informal groups, organizations, and/or subsystems. Diffusion occurs within the social system because the social structure of the system affects the diffusion of innovation in many ways. Rogers (2003) suggests that individuals can take different roles within these social systems. Opinion leaders provide other members of the social system with information and advice on innovations.

2.3.1.1 Roger Model of the Innovation Process in Organizations

Rogers (2003) defines the innovation process in an organization in five stages, two stages are in the initiation process, and three stages are in the implementation sub-process.

Table 3. Stages in the Innovation Process in Organizations

Stage in the Innovation Process	Major Activities at Each Stage in the Innovation Process
I. *Initiation:*	All of the information-gathering, conceptualizing, and planning for the adoption of an innovation, leading up to the decision to adopt.
1. AGENDA-SETTING	General organizational problems, which may create a perceived need for an innovation, are defined; the environment is searched for innovations of potential value to the organization.
2. MATCHING	A problem from the organization's agenda is considered together with an innovation, and the fit between them is planned and designed.
The Decision to Adopt	
II. *Implementation:*	All of the events, actions, and decisions involved in putting an innovation into use.
3. REDEFINING/RESTRUCTURING	(1) The innovation is modified and re-invented to fit the situation of the particular organization and its perceived problem, and (2) organizational structures directly relevant to the innovation are altered to accommodate the innovation.
4. CLARIFYING	The relationship between the innovation and the organization is defined more clearly as the innovation is put into full and regular use.
5. ROUTINIZING	The innovation eventually loses its separate identity and becomes an element in the organization's ongoing activities.

- **Agenda setting**

Agenda is common activity ongoing in every organization. Setting the agenda in innovation process helps to understand the initial motivation that what is the reason to take the subsequent steps for the innovation process. The motivation of setting innovation agenda can be problem oriented which means that one or more people in the organization identify an important issue and then seek innovation as a means of solving the problem. The issue can be a performance gap which means the difference between the expected performance and its actual performance. It can be a powerful driving force to pursue the innovation. The other type of motivation is not issue oriented, but some organizations have the tendency to look for the new ideas in the environment which can be beneficial to the organization.

- **Matching**

When an issue occurs and the organization wants to find an innovation to solve the problem, or when the organization tends to adopt an innovation just for its future benefits, it will enter the stage of matching. It means the organization needs to investigate how well they are likely to fit. It is a reality test by which the organization will exam the feasibility of the innovation in solving the problems. If the decision maker thinks that the innovation will fail to solve the problem, or the future benefits will be less than the input, the innovation activities will be rejected and terminated. However if the decision maker thinks that the innovation can be continued, then it goes to the next stage. Therefore, both agenda setting and

matching stages initiate the innovation process. All activities such as information gathering, conceptualizing, and planning lead up to the decision to adopt.

- **Redefining/ Restructuring**

The third stage comes to the implementation stage. Redefining or restructuring means the innovation and organization may need to adapt themselves in order to fit each other. On the one hand, if the innovation imported from outside does not exactly fit the organization's situation, it is necessary re-invent it so that it can be accommodated to the organization's needs and structure.

On the other hand, the structure of the organization may also need to change to accommodate the innovation. Sometimes new organizational unit is created for the responsibility of the innovation. For example, the introduction of automation technology may change the labor needed on a production line.

- **Clarifying**

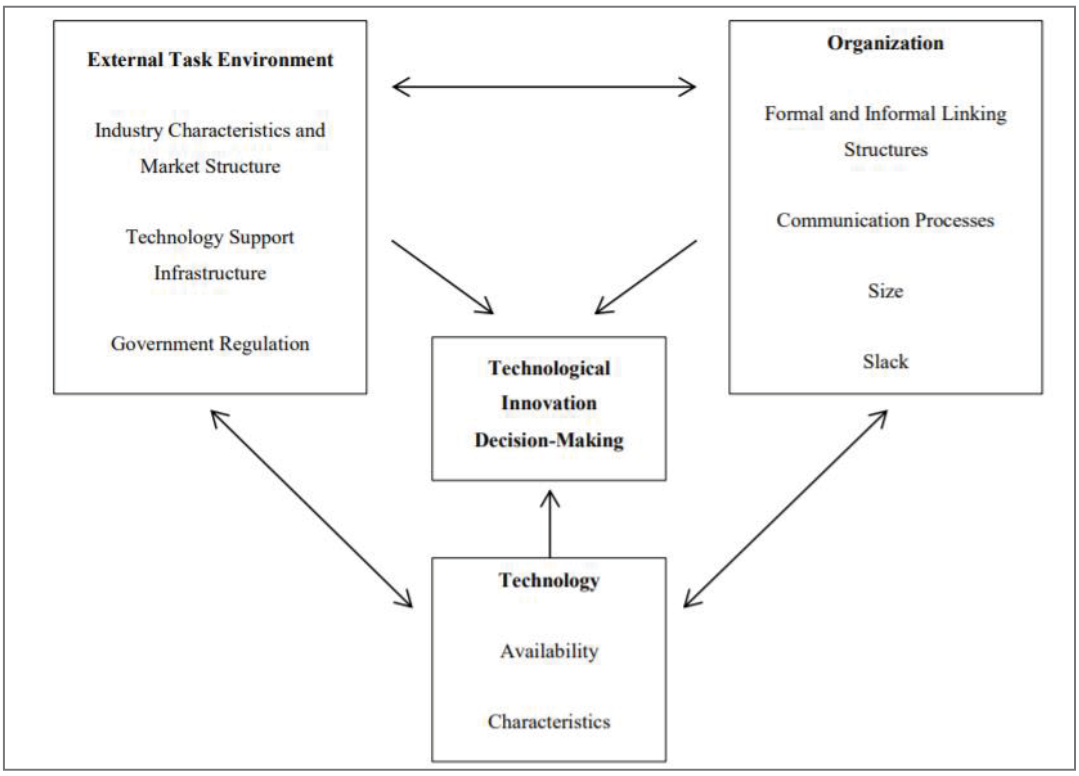
In this stage, the innovation is put into use more widely in the organization. With the more frequent usage, users are getting better understanding of the innovation. This stage is very important because it is the stage to identify the potential issues and to make corrective actions. Research shows that too fast implementation in this stage is risky because if the potential problems has not been identified but the implementation already move to the next stage, the bigger mistake may happen in the future.

- **Routinizing**

At this stage the innovation has become the regular activities of the organization. It is no longer considered independent of other organizational activities. The purpose of this phase is to ensure that innovation continues to be used after the implementation process. This stage marks the end of the innovation process.

2.3.2 The Technology-Organization-Environment Framework (TOE)

Figure 6. The context of the technological innovation



Another framework to see factors that affect organizations to adopt innovative technology is the Technology-Organization-Environment Framework (TOE) from Tornatzky and Fleischer (1990). The TOE theory considers three elements of innovation adoptions: technological context, organizational context and external environmental context.

- **The technical context**

The technical context contains all the technologies that are related to the company—both technologies that the company has adopted and those which are available on the market but the company has not adopted. Decisions to adopt technology depend on what is available as well as how the available technology fits with the firm's current technology. Different organization may face different technical opportunities. Not all innovations are relevant in all industries or in all plants. Some firms' industries are more mature and equipment change little from year to year. Other firms may face the opposite situation.

The number, quality and applicability of innovations available to a particular firm are understandably difficult to measure. The simple tally of the amount of R& D spending or even a count of available innovations does not fully describe the nature of a firm's technical opportunities. The characteristics of available innovations also influence adoption activity. The important point to look at such characteristics is how much they affect the information-processing or technology scanning function of the firm prior to adoption. The technological environment faced by a firm may

vary widely in its effects, even holding the absolute number or volume of technologies constant. Tushman and Nadler (1986) have developed a useful framework to discuss difference in innovations that have implications for adoption. They refined the product and process distinction (Hage 1980) into three additional categories:

1) Incremental changes are the changes that provide added feature or enhancements to an existing product or process. It introduces new features or new versions on existing technologies. These incremental innovations represent the smallest risks and changes in the adopting organization.

2) Synthetic changes are the changes that involve the combination of existing ideas or technologies in ways that create significantly new products or processes.

3) Discontinuous changes that involve the development of significant new products or process. Discontinuous innovations have also been referred to as radical.

Tushman and Anderson (1986) take this notion a step further, classifying the discontinuous innovation into two types: competence-enhancing and competence-destroying. competence-destroying shifts cause the technologies and expertise of a firm to become obsolete, resulting in major shifts in the industry. For example, the invention of integrated circuit leads to the isolation of wiring technologies. A competence-enhancing innovation is the one that provides the opportunity for a firm to radically improve a product or process, but will not cause the isolation for the

existed products or technologies. For example, Boeing 707 changed the traveling service hugely but it did not obsolete the other flight models.

The reason that these different categories affect adoption decision differently is because the uncertainty caused by the new technology is different, which will increase the information processing requirements of the organization. Thus, the organization may spend more time and money to learn more about the innovation and increase internal communication to reduce the uncertainty. Technological environments containing more radical, discontinuous innovations will require different reactions by the firms in that environment. The search process will be more difficult and more expensive, as will the nature of internal communications resulting from the search.

The internal technological context can affect the innovation process as much or more than the external context. The currently existing technologies in an organization are important during the technology adoption process because they affect the scope and speed when adopting new technologies (Collins et al., 1988). The researchers have counter results on which type of organizations adopt innovations more easily. Some found that those whose production systems were less highly developed initially tended to increase their level of automation over time. This suggests that less automated firms may attempt to leap-frog to a higher level of automation. While others found that more innovative and automated firms will tend to innovate more than less innovative ones.

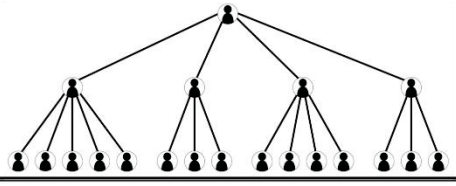
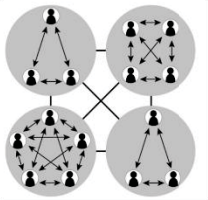
In short, organizations must carefully consider the types of organizational changes that the adoption of new innovations will bring. Some innovations will have a huge impact on the company and the industries it competes with, while others will have a relatively small impact.

- **The organizational context**

The organizational context refers to the characteristics and resources of the firm, including the organization structure, process factors and technological innovation, and organization size and slack.

Tornatzky and Fleisher look at the organization structure by using the theory of organic and mechanistic organization structure created by Burns and Stalker (1961). This table summarized the characteristics of mechanistic structure and organic structure:

Table 4. The characteristics of mechanistic structure and organic structure

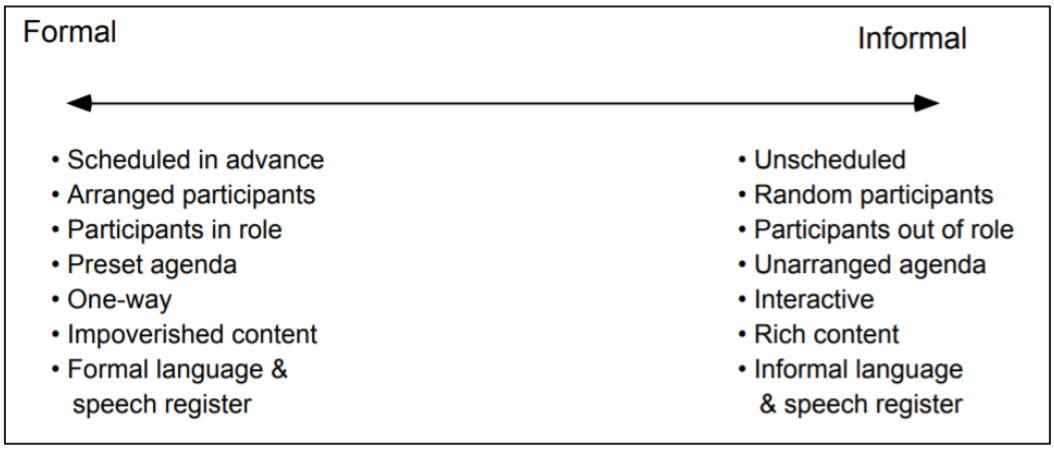
Mechanistic	Organic
	
Individual specialization: Employees work separately and specialize in one task	Joint Specialization: Employees work together and coordinate tasks
Simple integrating mechanisms: Hierarchy of authority well-defined	Complex integrating mechanisms: task forces and teams are primary integrating mechanisms
Centralization: Decision-making kept as high as possible. Most communication is vertical.	Decentralization: Authority to control tasks is delegated. Most communication lateral
Standardization: Extensive use made of rules & Standard Operating Procedures	Mutual Adjustment: Face-to-face contact for coordination. Work process tends to be unpredictable
Much written communication	Much verbal communication
Informal status in org based on size of empire	Informal status based on perceived brilliance
Organization is a network of positions, corresponding to tasks. Typically each person corresponds to one task	Organization is network of persons or teams. People work in different capacities simultaneously and over time

The table shows that the organic organization was characterized by frequent lateral communication between individuals and subunits, decentralization of leadership and control, and an overall high degree of networking between people and units. They studied the technological innovation in electronics and fiber industries and found out that an organic model of organization structure was more highly

associated with frequent adoption of innovations than was a mechanistic structure. Other researchers have found that organizations characterized by organic structures are more successful in introducing innovations (Aiken and Hage 1971). Several authors have attempted to disaggregate the gross concepts of organic and mechanistic into their constituent variables. For example, some empirical evidence relates formalization (number of rules and specified procedures) inversely to innovation (Rothman I974). In other words, the more formal in terms of procedures, roles, and the like, the less innovative the organization is likely to be.

The second characteristic of the organizational context is the process factors and technological innovation. When think about organizations, most people think of structure, but the events or processes that occur within the organization are as important as the structures themselves in providing a seedbed for innovation. Two processes appear to be key in establishing a positive environment for adoption decision making: informal linkage and communication, and top management strategic behavior. Informal linkages are direct person-to-person contacts, based on the need for collaboration between individuals. The table below shows the main features of informal communication and formal communication (Kraut et al, 2002).

Table 5. The formality dimension of communication



Informal internal linking agents are important not only because they serve a communication function, but because they provide the energy and labor so necessary for later adoption and implementation activities. These internal linking agents have also been found to act as bridges between different phases of the decision process about technological innovation, including early pre-adopting decisions, such as whether information about a new technology enters a firm and is diffused throughout, as well as the actual decision to adopt (Chakrabarti 1974; Chakrabarti and Souder 1984). Chakrabarti (1989) has found that these informal roles are dynamic, not static: individuals change roles depending on the situation. For example, information promoters have been found to take on the role of power promoters to quicken decision making about adoption and implementation.

Another key process in establishing a positive environment for innovation adoption decision making is top management strategic behavior. Top management leadership

behaviors include planning and communication of change and the development of policies and goals that support innovation (DeMeyer 1985; Daft 1982). Tushman and Nadler (1986) recommend five specific ways in which top management can promote innovation:

1) Develop and communicate a clear image of the organization's strategy and core values, and the role of innovation in meeting that strategy. If this is not done, the organization's focus will be on the status quo.

2) Serve as a role model and send consistent signals to subordinates about the importance of innovation. Too often, an inconsistent signal is sent when management claims that innovation is important but does not provide sufficient resources or adequate personnel.

3) Use formal and informal incentives to reinforce innovation.

4) Build a sense of innovation throughout the organization's history to create an organizational culture based on innovation.

5) Build an executive team with the technical, social, and conceptual skills to accomplish different tasks and actively work to envision a credible and exciting vision of the future.

The third characteristic of the organizational context is organization size and slack, which are two variables that have received a great deal of attention in the innovation literature.

The availability of slack resources is often presumed to be important in understanding technological innovation. March and Simon (1958) suggest that many complex innovations never get implemented because of the lack of such resources, while others suggest that slack may be a necessary, but not sufficient condition for innovation (Cyert and March, 1963, Rogers, 1983). Characteristics of the external task environment and organization will affect how, and if, slack resources are used. For example, the external task environment might lack information about specific technological innovations. or key players in an industry might be observing the experience of early adopters to assess the cost and benefits of adoption (Downs and Mohr 1976). Under these circumstances, firms may simply wait to see how things play out before making a commitment. Consider the behavior of many firms when personal computers first arrived in the early 1980s. Many waited until there was an established standard before making any purchase, despite the low costs involved.

Different types of slack may have different effects. For example, slack financial resources are qualitatively different from slack human resources. Many firms that run a very lean operation, with a bare minimum of personnel, may have high profits and money to spend, but lack personnel to take the necessary actions. Thus, it is important to realize that organizational resources are fungible, in that they can be taken from one area and moved to another. Thus, a firm may decide to reorient its priorities, taking resources away from an existing activity and applying it to an

innovative one. So, slack can be created for some part of the organization, even though the organization as a whole has none.

As for the size of the organization, there are contrary opinions on how it affect innovation adoption. Some researchers found that larger organizations are more likely adopters (Kelley and Brooks, 1988). While some believe that any aggregate index of size (number of employees, amount of budget, gross receipts, etc.) is correlated with other intra-organizational variables to some degree, but does not reflect directly the degree of vertical hierarchy, the degree of internal complexity, or similar variables, or capture much about the process of internal decision making.

- **The external environmental context**

The organizational part of the framework relates to the internal environment of the organization, while the external environment part relates to the external environment of the organization. This part consists of industry characteristics and market structure, technology support infrastructure, and government regulations.

The industry characteristics and market structure refer to the firm size, intensity of competition, customer-supplier relations, market uncertainty or volatility, the dimension of company, and industry life cycle.

Large firms are perhaps more likely to achieve the economies of scale required to make an investment in new equipment profitable. In addition, large firms may be involved in a greater variety of production activities, and thus be more likely to find any given innovation applicable to their operations. The intensity of competition is

measured by market concentration, which is the percentage of output contributed by the four largest companies in an industry. The higher the concentration of an industry, the more the market is dominated by several very large companies. For the customer-supplier relations, many organizations not only face fierce competition from competitors in the industry, but also have to deal with powerful buyers or suppliers. Leading customers can sometimes dictate the use of technology by the companies that serve them. For example, Kamath and Liker found that in automotive industry, when customers' innovation goals are clear--that is, when they know what innovations they expect them to make, the dependent suppliers (more than 60% of their sales are for automotive customers) tend to have more innovation activities, while the independent suppliers are not affected by this. Next aspect of industry characteristics and market structure is the market uncertainty or volatility. However, the effect of uncertainty on innovation is unclear. Companies may seek innovation to protect themselves from uncertainty; other companies may hoard available resources and avoid further risky activities if difficulties may come. The fifth aspect is the dimension of competition. Differences in the competitive importance of price, quality, and services may affect the type of innovation that companies seek. They will strive to pursue technology strategies and policies that are consistent with its overall business objectives. For example, companies that consciously aim to provide and emphasize excellent customer service instead of low prices may be more likely to invest direct electronic communication with their

customers rather than saving this cost. Finally, companies operating in fast-growing industries should incorporate new innovations into their operations more quickly.

The second part of external environmental context is technology support infrastructure. The constraints or opportunities that a firm must take into account when developing its technology acquisition strategy depend on the quality and availability of the external resources from which the firm can draw. In particular, bringing in new technology depends on labor costs, skills of the available labor force, and access to suppliers of technology-related services. Firms paying higher wages are almost always more likely adopters of new technology. This can be explained that higher wages should stimulate the use of innovations designed to replace labor (Levin, Levin, and Meisel 1987). New technologies generally require changes in the skills that firms demand from their employees (Flynn 1988). Firms operating in a labor market with an abundance of trained, experienced employees face substantially smaller innovation-related training and requitement costs. Often the most efficient way for a firm to accomplish the host of decision-making, adoption, and implementation tasks associated with new technology is to delegate some to outside specialists. Firms operating in industries or geographic areas with topnotch, low-cost suppliers of technology-related training and consulting have more options, and more flexibility in carrying out their innovation strategies.

- **The government regulations.**

The last part of external environmental context is the government regulations. Research shows that government regulation can have either a beneficial or a detrimental effect on innovation. When the government imposes new restrictions on the industry, such as requiring energy companies to apply pollution control devices, the innovation of these companies is basically mandatory. Similarly, strict safety and testing requirements will hinder innovation in many industries.

2.3.3 Innovation Maturity Model

The maturity model is designed based on the concept that competency enhancement is not an overnight process, but a gradual, step-by-step process. The core idea of the maturity model is continuous process improvement, which decomposes the capability enhancement into several levels. In each level there is a corresponding key process domain. The level is reached and when all the key process domains of a certain level are completed and the capability is continuously enhanced. Because of the practicality and effectiveness of the maturity model, the research on the maturity model is increasing, among which the software process capability maturity model is more popular and has become a standard in the software industry.

- **Capability Maturity Model (CMM)**

In November 1986, SEI, with the assistance of MITRE Corporation, began developing a process maturity framework to help organizations improve their software processes. SEI started this work in response to the request from the federal

government to provide a methodology for evaluating the capabilities of software contractors. In September 1987, SEI published a short description of the software process maturity framework, which was soon expanded in Humphrey's book: Managing the software process. Humphrey developed two methods based on SEI framework which are software process assessment and software maturity evaluation, together with a maturity questionnaire to estimate software process maturity.

The CMM is a framework that describes a path to improvement for software organizations that want to improve their software process capabilities. The CMM serves as a descriptive model that describes the key characteristics that characterize a software organization at a given maturity level, and a formal model that details the types of behaviors expected of organizations working on large projects in the context of government contracting. The CMM has been in place since 1987 and is now the software industry's most authoritative assessment and certification system that helps companies answer three questions: What is the current level of their software process? What must be done to improve the process? Where to start? The structure of the maturity model is shown in the figure below, which consists of two main aspects: one is the maturity levels, and the other is the internal structure. The internal structure includes Key Process Areas (KPA), Common Features (CF), and Key Practices (KPP).

Figure 7. Hierarchical Structure of the Capability Maturity Model

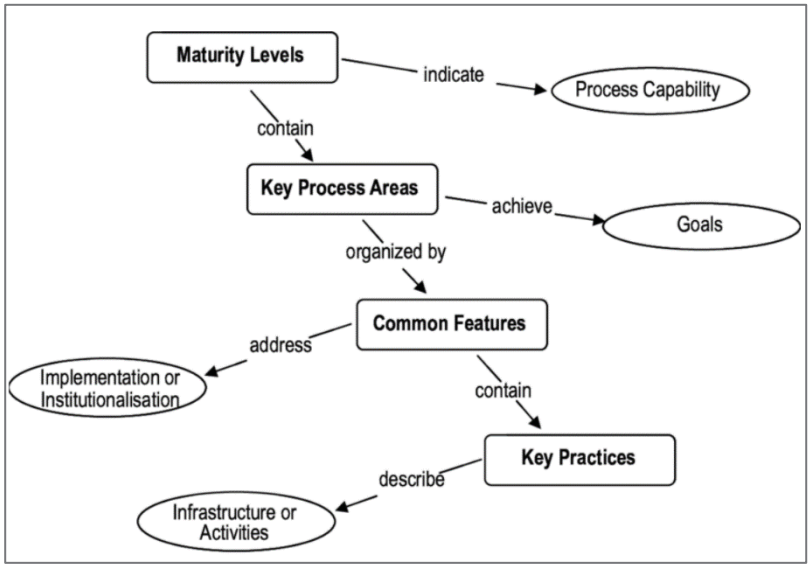
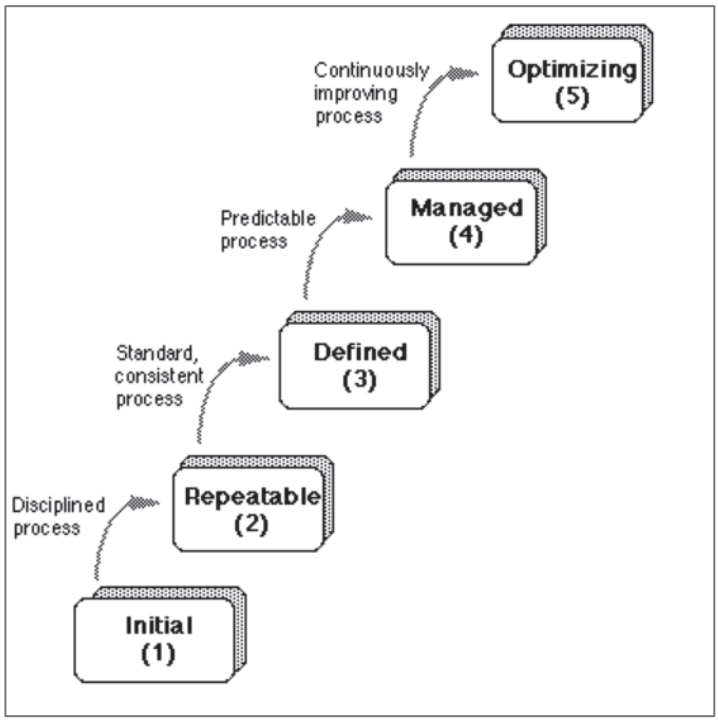


Figure 8. The Five Levels of Software Process Maturity



The maturity levels are an evolutionary platform used to implement the software maturity process. The five maturity levels provide the top-level structure of the CMM. Software process capability describes the range of expected results that can be achieved by following a software process. An organization's software process capability provides a means of predicting the most likely outcome of the organization's next software project. Each maturity level is comprised of key process areas. Each critical process area identifies a set of related activities that, when performed together, achieve a set of goals that are considered important for establishing process capability at that maturity level. Critical process areas have been defined as being at a single level of maturity. For example, one of the key process areas at Level 2 is software project planning. The objectives summarize the key practices for a given critical process area and can be used to determine whether an organization or project is effectively implementing that critical process area. These objectives mark the scope, boundaries, and intent of each critical process area. The critical practices are divided into five common characteristic sections. Commitment to Execute, Capability to Execute, Activities to Execute, Measurement and Analysis, and Validation of Execution. Common characteristics are attributes that indicate whether the implementation and institutionalization of a critical process area is effective, repeatable, and durable. The Common Characteristics of Performed Activities describe the activities that have been performed. The other four common characteristics describe the institutionalized

elements that make a process part of the organizational culture. Each key process area is described by key practices that, when implemented, contribute to the achievement of the goals of that key process area. The key practices describe the infrastructure and activities that best facilitate the effective implementation and institutionalization of the key process area.

2.4 Business model

As an emerging concept, business model has attracted attention after the Internet was born. In recent years, scholars have conducted more and more researches on business models, and their research scope and fields have become broader. Business model research has also achieved certain results. However, no consensus has been reached on the definition of business models so far. Here is a selection of various business model definitions excerpted from Vial. V (2016):

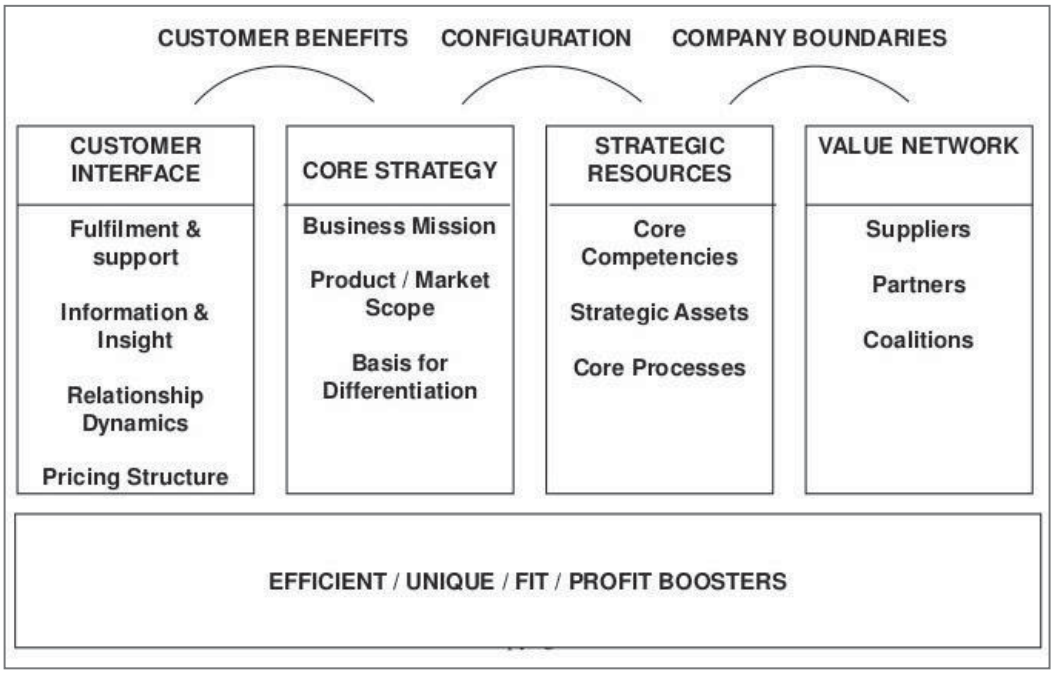
Table 6. A selection of various business model definitions

Authors	Business model definition
Timmers (1998)	"A business model is an architecture for product, service and information flows, including a description of the various business actors and their roles" (p. 4).
Amit & Zott (2001)	"A business model depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities" (p. 493).
Chesbrough & Rosenbloom (2002)	"The business model provides a coherent framework that takes technological characteristics and potentials as inputs and converts them through customers and markets into economic outputs" (p. 532).
Magretta (2002)	"[Business models] are, at heart, stories—stories that explain how enterprises work" (p. 87).
Mangematin et al. (2003)	"Each business model has its own development logic which is coherent with the needed resources—customer and supplier relations, a set of competencies within the firm, a mode of financing its business, and a certain structure of shareholding" (p. 624).
Downing (2005)	"[The business model] is a set of expectations about how the business will be successful in its environment" (p. 186).
Morris et al. (2005)	"The model represents a strategic framework for conceptualizing a value-based venture" (p. 734)
Osterwalder et al. (2005)	"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams." (p.10)
Casadesus & Ricart (2010)	"The logic of the firm, the way it operates and how it creates value for its stakeholder"
Demil & Lecoq (2010)	"The way activities and resources are used to ensure sustainability and growth"
Gambardella & McGahan (2010)	"Business model is a mechanism for turning ideas into revenue at reasonable cost"
Itami & Noshino (2010)	"…business model is a profit model, a business delivery system and a learning system"
McGrath (2010)	"The business model construct offers some intriguing opportunities to capture better how a given set of resources translates into something a customer is willing to pay for. Which brings us to two core components of what constitutes a business model. The first is the basic 'unit of business', which is the building block of any strategy, because it refers to what customers pay for. The second are process or operational advantages, which yield performance benefits when more adroit deployment of resources leads a firm to enjoy superior efficiency or effectiveness on the key variables that influence its profitability" (p. 249).
Sabatier, Rousselle & Mangematin (2010)	"Cross roads of competence and consumer needs"
Teece (2010)	"How a firm delivers value to customers and converts payment into profits"
Williamson (2010)	"… cost innovation business model offers advantages in radically new ways meaning more for less"
Yunus, Moingeon & Lehmann- Ortega (2010)	"A value system plus a value constellation"
Zott & Amit (2010)	"…a system of interdependent activities that transcends the focal firm and spans its boundaries"
George & Bock (2011)	"The underlying dimensions of the business model are resource structure, transactive structure, and value structure" (p.83)

The following part listed out a few business model frameworks that are more representative in the field.

The first is Hamel's business model framework. Hamel (2000) argues that to become a revolutionary in an industry, companies must develop an instinct to think holistically about their business models. He created a complete but simple business model framework, as shown in Figure 7. This framework consists of four main components: core strategy, strategic resources, customer interface, and value network, each of which has subcomponents. These four core components are linked together by three "bridge" components: the activity configuration that connects the core strategy to the strategic resources, the customer benefits that connect the core strategy to the customer interface, and the company boundaries that connect the strategic resources to the value network. Underpinning the business model are four factors that determine its profit potential: the efficiency of the business concept in delivering customer benefits, the uniqueness of the business concept, the fit between the elements of the business concept, and the profit enablers utilized by the business concept. This framework contains many strategic elements that are valuable for companies to leverage external opportunities and their own resources and capabilities, provide superior customer value, and avoid blind spots in business model innovation.

Figure 9. Hamel business model framework



The second framework is from Shafer, Smith, and Linder (2005). They identified 42 different business model components in 12 definitions for the period 1998-2002 and grouped them into four main categories: strategic choice, value creation, value capture, and value network, as shown in the table 7. However, their components of the business model appear to be discrete, at least in the sense that the linkages between these components are not clearly identified, nor are the existing linkages described and represented.

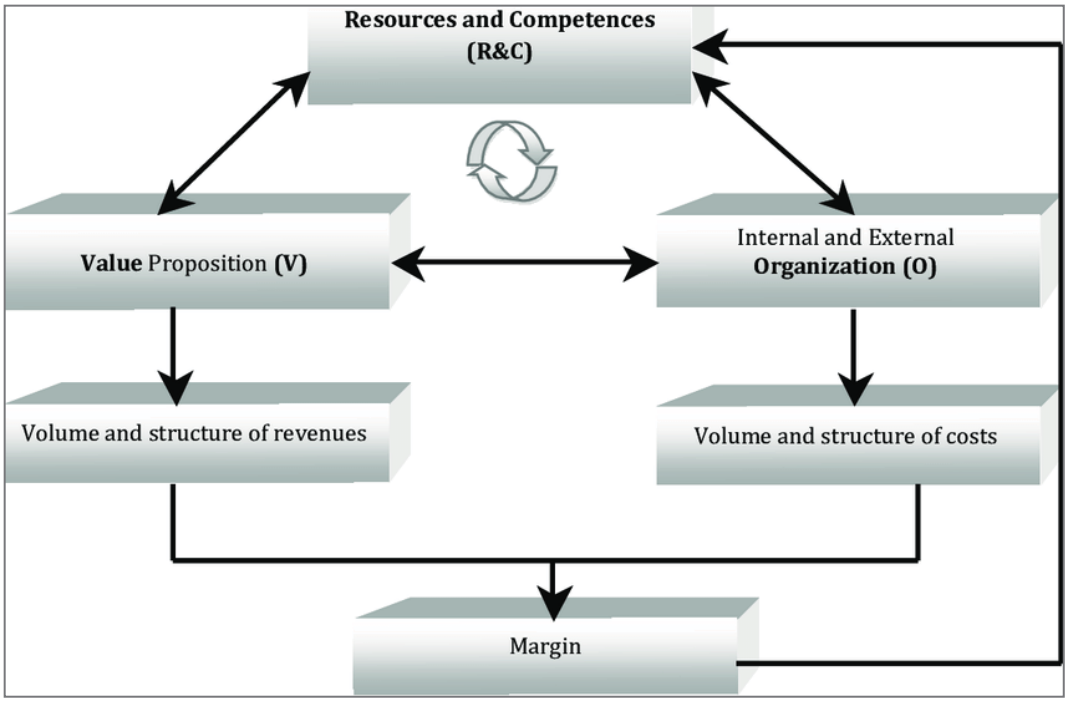
Table 7. S.M. Shafer, H.J. Smith, J.C. Linder, the power of business models, "Business Horizons" 2005, No.48.

Strategic Choices	Value Network
Customer (target market, scope) Value proposition Capabilities / Competences Revenue / Pricing Competitors Output (offering) Strategy Branding Differentiation Mission	Suppliers Customer information Customer relationship Information flows Product / Service flows
Create Value	Capture Value
Resources / Assets Processes / Activities	Cost Financial aspects Profit

The third is RCOV model from Demil and Lecocq (2006). They developed a framework (see figure 8) that attempts to unify the static and transformational uses of the concept of business model in order to examine the dynamics of business model evolution and particularly, the interactions between business model components. They hypothesize that a business model can be described by three core components: resources and capabilities (RC), organization (0), and value proposition (V), and that each core component includes several different elements. The RCOV framework forms a simple, dynamic approach to business models. In this framework, the continuous dynamic evolution of the business model arises from the interactions between and within the core components. Business model evolution is a fine-tuning process involving spontaneous and unexpected changes

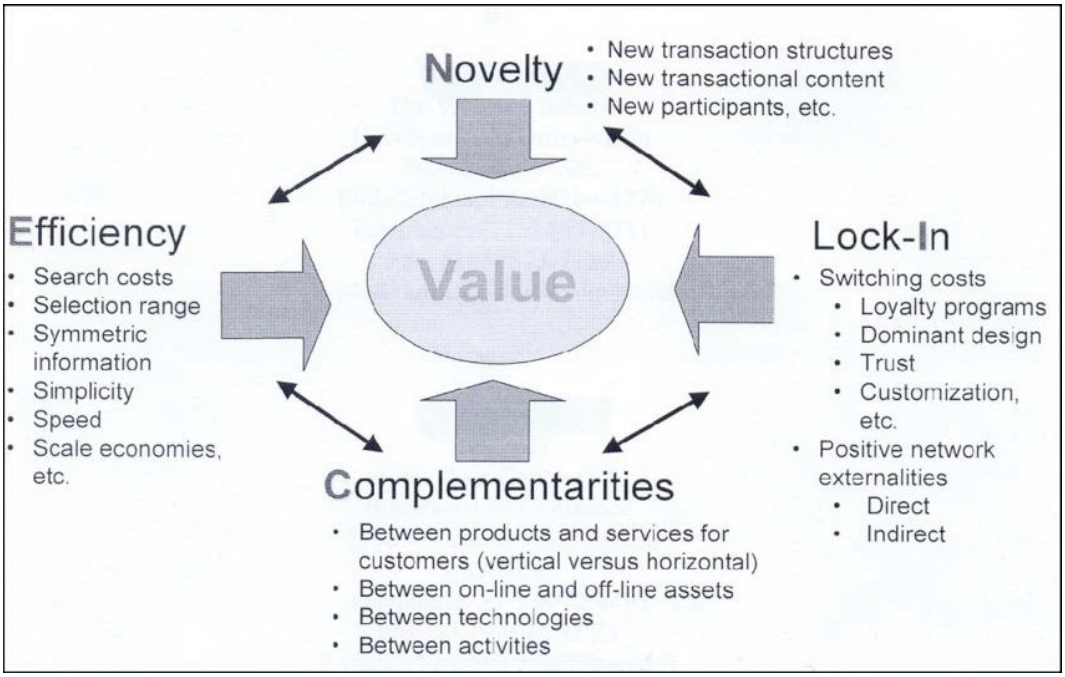
within and among the core components that are connected together. They found that the continuity of a company depends on its expectations and responses to spontaneous and unexpected sequences of change. They call the company's ability to establish and maintain its performance while changing its business model as "dynamic consistency" (Demil, Lecocq, 2010).

Figure 10. The RCOV model



The fourth is from Amit and Zott. After studying 59 e-commerce firms in Europe and US, Amit and Zott (2001) proposed four categories of e-commerce firms' value creation sources: Efficiency, Complementarities, Lock-in and Novelty, as shown in figure 9 below. Based on the analysis of these sources of value creation and related theories in the field of strategy and entrepreneurship, they suggest that business model can be used as a unit to analyze. They believe that business model is the design that depict the content, structure, and governance of business transactions to create value by exploring business opportunities. Business models can capture these four types of value creation sources for e-commerce firms and apply them to virtual marketplaces. Among them, transaction content refers to the products and information being traded, as well as the resources and capabilities needed to enable these transactions to occur; transaction structure refers to the members involved in the transaction process and the way these members are connected; and transaction governance refers to the way the relevant members control the flow of information, resources, and products. Another major contribution of their study is to point out the validity of the business model concept as it can explain and predict practices that cannot be explained by other existing analytical frameworks, such as value creation in e-commerce.

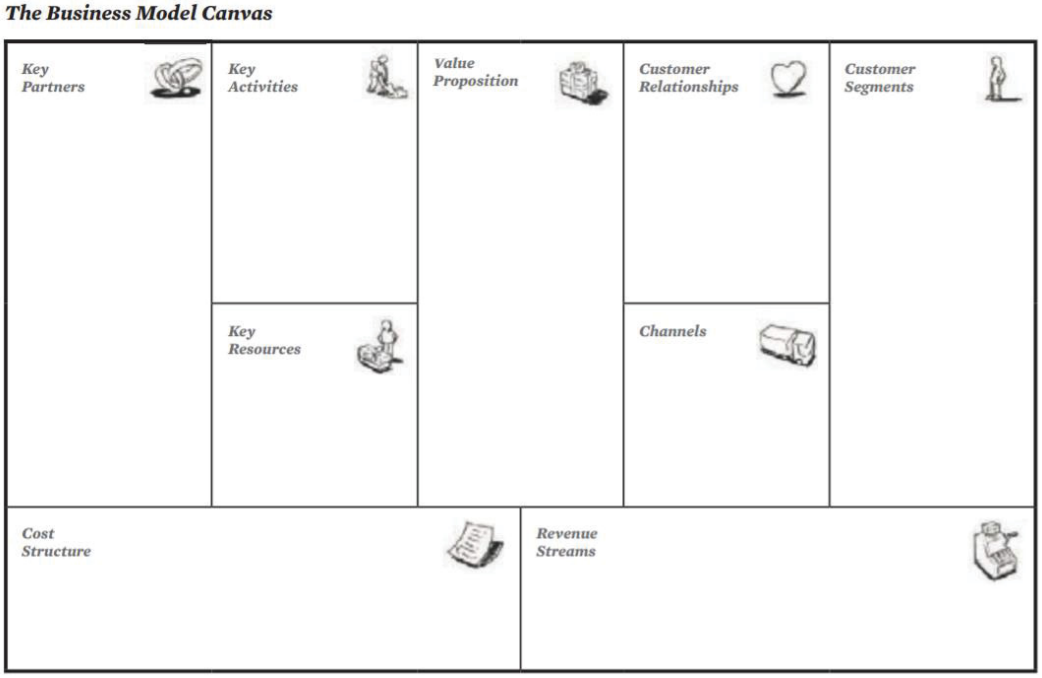
Figure 11. Amit and Zott (2001), Drivers of Value Creation in E Business



The last one is the Business Canvas Model which is developed by Alexander Osterwalder and Yves Piguer. They introduced this tool for analyzing business models in their book "Business Model Generation". It states that Canvas is a tool that helps companies innovate, find precise users, and use resources wisely to create value. It provides a graphical and intuitive depiction of a company's operational mechanisms and value creation logic, as shown in figure 10. The model contains four pillars and nine elements. The four pillars are the four interfaces: product or service, customer, finance, and asset management. The product and service interface refers to the Value Proposition; the customer interface has Customer Relationship, Channels, and Customer Segments; the financial interface contains

Cost Structure and Revenue Stream. The financial interface includes Cost Structure and Revenue Stream; the asset management interface covers Key Activities, Key Resources, and Key Partnerships. Value proposition refers to what products or services a company provides to a specific market or organization and what problems it solves; customer relationship refers to the type of relationship a company has with a specific group of people or organization; channel refers to the way a company communicates and reaches its customers, and the channel through which it delivers its value proposition; customer segmentation refers to the specific group of people or organization a company wants to reach and serve; revenue source refers to the specific Core resources are the key assets necessary to ensure the effective operation of the business model, usually the company's strengths or the key success factors required for a particular industry; key partnerships are the suppliers and business partners necessary to ensure the effective operation of the business model; key operations are the important activities performed to ensure the survival and growth of the company and the effective operation of the business model; cost structure The cost structure refers to all the costs that a company has to pay in a given business model.

Figure 12. Business Canvas Model



Chapter 3. Methodology

This chapter reflects the methodology process which is adopted to deal with the research questions. The dissertation adopts inductive and interpretivism approach and a case study research strategy. Quantitative method is used.

3.1 Research philosophy

To achieve the aim of the research, the inductive approach and interpretivism approach will be used in this dissertation. In deductive approach, there has existed a theory which leads to a hypothesis, the research then collect data to test if the result confirms the hypothesis. While in inductive approach, theory will be developed after the results of the research (Bryman and Bell, 2015). This dissertation will conduct an inductive approach because it tries to find out how a specific group of people evaluate their training program. The conclusion only can be made after the research.

As for research philosophy, it reflects how researchers develop the process and establish the view of research. Different philosophies may take different strategies and methods during the research. It also influences how researchers interpret the data. Ontology and epistemology are the two main types of research assumption. Ontology asks the question of what the world is, looking at the nature of the reality. On the contrary, the latter asks the question how we know the world, which accentuates the knowledge (Saunder et al., 2016). On the grounds of these two

philosophy assumptions, two methodologies are developed, which are subjectivism and objectivism. Subjectivism holds the view that how people look at things is affected by perception of people, which means that people's conception and interpretation will influence how people look at world. While the objectivism argues that things are independently existing in the world. They are facts which will not impacted by human thoughts (Saunder et al., 2016). The combination between philosophy assumption and two abovementioned methodologies stretches a series of philosophy approaches. This research takes the approach of interpretivism. Interpretivism believes that people have consciousness and awareness so people are different from physical entities (Saunder et al., 2016). Researchers who take this approach interpret the study, trying to look at and understand the world through its context. It takes qualitative analysis more than quantitative analysis.

3.2 Research strategy

The research will conduct the strategy of multiple case studies. Robert Yin (2003) describes case study as "case study is a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence" (as cited in Robson, 2003, p178). In case study, a 'case' is a situation or a phenomenon that you are interested in, no matter it relates to people or organization (Robson, 2003). Anything can compose a 'case'. Previous studies conclude three situations that are suitable for the research

of case study. The first situation is when questions have specific symbols such as ‘how’ or ‘why’. The second characteristic is that the researcher needs to keep neutral from the context, without controlling the process of the study. It is an empirical investigation to explore what happened behind the phenomenon. One advantage of case study is that it can help researcher to understand better of the situation than other research method. It is helpful to diagnose some unique factors which may be the keys to understand the circumstances. Large scale investigation may ignore this point, for example, though survey is conducted in a large scale, it is hard to explore the deeper reasons (Nisbet and Watt, 1984).

Stake came up with three types of case studies, including intrinsic, instrumental and collective (Stake, 1995). Researchers who aim to study a single and unique situation would carry out intrinsic case study. The reason why the situation is identified as unique should be given. The instrumental case study is carried out usually to take a general understanding of the phenomenon. The collective case is several instrumental cases. Based on the number of the units and the context, Yin(2003) classified case study into single case study and multiple case study. If there are more than one cases in a study, it is a multiple case study. Learning a unique situation or unique phenomenon usually takes intrinsic case study. While the instrumental case is to obtain a general understanding of a situation. The collective case is a gather of instrumental cases. Yin (2003) classified case study into single case study and multiple case study based on the number of context and units. Multiple case study

contains more than one case, through which researchers can find the similarities and differences by looking at different cases. Multiple case study has the advantage of more convincible due to the number of cases. However, the disadvantage is it is more expensive and may take more time. The embedded case study is a single case study which is embedded more than one unit. Researchers can get more information by looking at multiple sub-units. On the contrary, holistic case study focuses on the single unit (Yin, 2003). This research takes a holistic case study.

3.3 Research methods

Quantitative method is a kind of research method which involves in dealing with data using mathematical methods, such as the collection and analysis of numeral data. Contrary to the quantitative method, qualitative method is a process to gather information without numerical data. Usually words are the most common form in qualitative research, such as interview. However, quantitative method and qualitative method are not conflicting. The combination of both methods is regarded as a good way to get more accurate result (Elman, 2009). This dissertation will collect data by using qualitative method. This research use semi-structured interviews.

3.4 Ethic consideration

Ethics relates to “the standards of behavior that guide your conduct in relation to the rights of those who become the subject of your work, or are affected by it”

(Saunder et al., 2016, p239). There are several ethical issues which need to be taken into considered. First, both participants and researchers, their well-being and safety should be guaranteed. Second, only after the consent of the participants, can the research be conducted. The private information of the participants should be protected and respected, especially when the topic is sensitive. Another key aspect is to collect and store the data in a safe place.

Chapter 4. Empirical study

4.1 Case 1

The first company is a manufacturing company located in Osimo, Italy. It is a sub-company of a group in Luxembourg which is established in 1976. The group has been manufacturing electromechanical products for the automotive and household appliance industries. The group product range covers components for temperature control and micromotors such as temperature sensors, fan motors, actuators for various applications or DC and gear motors. The group has more than 3000 employees worldwide.

The company in Italy produces automotive components such as hood latches, tailgate latches, washing system, and actuators. The customers include Volkswagen, Stellantis, Daimler etc. The site in Osimo has around 150 employees. Its turnover in 2021 is around 120 million euro.

The company has one plant where all these activities are included: manufacturing, testing, packaging, and delivering. The interview has been conducted with key managers in sales department and in production line.

First question is to let the company listed out what digital technologies they have adopted and what did not.

Table 8. Digital technologies adoption in Case1

Digital technologies	No plan to adopt	Consider to adopt in the future	Already adopted
Internet of things	☐	☐	√
Cloud computing	☐	☐	√
Big data	☐	√	☐
Virtual and Augmented reality	☐	√	☐
Additive manufacturing	☐	√	☐
Cybersecurity	☐	☐	√
Integrated systems	☐	☐	√
Simulations	☐	√	☐
Autonomous robot	☐	☐	√

Table 8 shows the digital technologies adoption situation in this company. So far, the company has adopted internet of things, cloud computing, cybersecurity, integrated system, and autonomous robots. The technologies that the company is considering adopting in the future are big data, virtual and augmented reality, additive manufacturing, and simulations.

For the technologies that have been adopted, table 9 shows the application and the capacity of each technology.

Table 9. Digital technologies applications of case 1

Digital technologies	Applications	Actual /Objective (%)
Internet of things	1. Production efficiency data	100%
	2. Anomaly data	30%/100%
	3. Process data	50%/100%
Cloud computing	1. Creating a Data Center At The Time	0%/80%
	2. Remote assistance on production line	100%
	3. Saleforce software	100%
Big data	1. Data collection of efficiencies and productions, process and testing	50%/100% (under planning)
	2. Analysis of collected data	20%/80% (under planning)
Virtual and Augmented reality	1. Remote assistance from external suppliers	20%/100% (under planning)
Cybersecurity	1. Management server backup systems	100%
	2. TISAX Certification	100%
	3. internal-external file sharing system	100%
Integrated systems	1. Traceability of raw materials	5%/30%
	2. Traceability of the finished product	30%/100%

Simulations	1. Optimization of process parameters	0%/30% (under planning)
	2. Digital Twin	0%/30% (under planning)
Autonomous robot	1. Automation robots in the production line	80%
	3. Automatic loading	80%

For the benefits that the company has felt after the adoption of digital technologies, the first benefit is more convenient obtain the data and use the data collaboratively. The second benefit is the integration of production chains and supply chains. Other benefits include the increasement on the productivity, better product quality and less production waste.

This part will show how the digital technologies have changed the business model. For the key partners, more than 50% of the revenue is from one single client. Actually this happened before the mass adoption of digital technologies, so on the key customer it doesn't change so much. However, the usage of automation on production lines and assembling lines hugely increase the quality and range of products, which help the companies also obtain more other customers, even though the contribution to the revenue is not as centralized as the biggest one. Also, with the expansion of the company's scale and the increasement of product demand, the company works more closely with its suppliers, and several suppliers have been verticalized by the company.

For the company key activities, one of the most important competences is to customize the product as the clients want. This not only means to customize the design, but also need to do the full set of testing to the product including corrosion resistance, durability test and so on. The automation machine and advanced testing equipment is very essential in these activities, so for the company the digital technologies are very important.

For the value proposition, the company's strategy is to provide customized product with top quality. Now the company is facing the pressure of customer request on cost reduction, but this is not caused by digital technologies. So digital technologies allow the company design and innovate the products with better quality to obtain the clients and generate the value.

For the customer relationships, as mentioned above, more than half the revenue comes from one key client. The company at beginning supplies one type of product, with the improvement of production capacity and ability of innovation, now the company sells around 5 types of products to this company. Apparently, this client is the key account and the company sets more human resources on maintaining this client. The success with this key client also brings the optimistic impact on the other clients too. The other point is the usage of Saleforce software to manage the clients worldwide. Because the group has international subsidiaries and the clients have plants worldwide, how to manage all these information among all colleagues worldwide is important. The company bought the service of Saleforce and

customize the function. Thus, the front sales people who contact the client directly can input the customer information and all related colleagues are able to share the information, especially for the back office like technical departments or quality control departments, who play a very important role in maintaining customer relationship.

For the customer segments, the company only focus on the top 20 car makers which can create a high volume for the business. Small scale clients' requests with low volume always are overlooked. The mass production allows the company to do so to obtain higher revenue.

The key resources of the company are the intellectual property of the products and the reliability of mass production with high standard quality. Among the 4 main products, one product accounts more than 50% of the total revenue. The reason why it has the leading position in the industry is because the patent is protected.

For the channels, the way company obtain clients is to assign sales representatives in the cities where locate the main car makers. The digital technology that has changed the way to obtain more client opportunities is the use of cloud computing-salesforce software. As mentioned before, the software allows sharing information in time among all sales persons worldwide. For example, an American car make has subsidiaries in China, the sales person from China visited this client then established a business case in sales force. The American sales person catch some key information from this visit report and finally get the contact information of

American company. So it proves that the use of digital technologies do help the company has more channels to obtain the clients.

The cost structure of this company can not be singly identified as cost-driven or value-driven. The base is value-driven which means to provide value for the customer. But at the same time, like talked in the customer segments part, this company only focuses on high volume order, which allows the company realize the economies of scale that in turn reduce the cost. The application of autonomous production line and high technologies definitely help the company in achieving this goal.

The revenue streams also have been changed. Now, most of the production machinery is paid for the clients. Since the company has established a stable relationship with one key client, so the client is willing to pay for the investment of the machinery. And because the company has these machines, so in the future it is much easier to win other orders from this client because the client doesn't need to pay for it again. So it is easier than before to get a higher margin from every piece of product.

For what will do in the future to adopt more technologies and what are the challenges, the company first confirmed that they have gained benefits from all the digital technologies adopted and because the business is growing these two years, so they are willing to continue implement other technologies. But this can be a long process because it needs the management level to make the decisions. They also

mentioned that the challenges are how to collaborate these systems in a better way. For example, there are several systems obtain production data in different formats for employees in different departments. Every department has a different requirement of the data so the IT developers have developed a lot of surface, which causes some confusions too. So in the future the company hopes to have a better way to integrate all the digital information.

4.2 Case 2

The second company is a plastic manufacturing company located in Senigallia, Italy. The company is established in 1992. It has 30 employees. The turnover in 2021 is around 12 million euro. It produces plastic blankets, garbage bags, signage tapes, sheets and packaging materials. The products are sold in both Italy and countries in Europe. The plant has 10 production lines in total. The key findings are as follows.

As shown in table 2, among the 9 digital technologies, company No.2 adopted cloud computing, cybersecurity and autonomous robot. It is considering to adopt bigdata, and integrated systems in the future. The rest of technologies will not be considered in the future for now. For cloud computing, the company bought the service of Teamsystem software. The machinery in production line is connected with the software so that the real time bidirectional data interchange from production to the company management software. Also, the software helps the company conducts administrative works. For the cybersecurity, the company doesn't have the IT expertise, instead, it outsourced the service

to an supplier to manage information technology services, including cybersecurity monitoring. The most used digital technology in this company is the autonomous robot on its production line. Due to the beneficial policies of Industry 4.0 in Europe, the company already realized 90% of the production line with automation.

Table 10. Key findings of Case 2.

Digital technologies	No plan to adopt	Consider to adopt in the future	Already adopted
Internet of things	☐	☐	☐
Cloud computing	☐	☐	√
Big data	☐	√	☐
Virtual and Augmented reality	√	☐	☐
Additive manufacturing	√	☐	☐
Cybersecurity	☐	☐	√
Integrated systems	☐	√	☐
Simulations	√	☐	☐
Autonomous robot	☐	☐	√

Table 11. Case 2 digital technology applications

Digital technologies	Applications	Actual /Objective (%)
Cloud computing	1.Cloud management system for administrative part	50%
	2.Management of commercial data in cloud through app	50%
Cybersecurity	1. Outsourced cybersecurity management to partners offering management information technology services, including cybersecurity monitoring.	80%
Autonomous robot	1. Commissioning of an automatic palletizer and a new packaging line in view of Industry 4.0	90%

For the question which benefits are being experienced in the company as a result of adopting 4.0 technologies, the company believes that by using the automation robots and cloud computing, they obtain the data more easily and faster. The data also helps to integrate production and supply, which allows the company reacts faster to the market. With the automation in product line, the quality of the products have been improved greatly and the production waste has been reduced. These improvements shows that there is also an improvement on the financial results.

Then the questionnaire asked about how the business model has been changed before and after the adoption of the digital technologies. For the key partnership, the company believes that the introduction of digital technologies has made it possible to increase productivity and target new sectors and customers, produce higher quality products and optimize procurement processes by working with more effective forecasting budgets. For the key activities, the adoption of digital

technologies has enabled an increase in product quality and more accurate estimation of market trends, as well as much higher productivity, allowing us to create close partnerships with top-tier customers in our industry that we would not otherwise have been able to serve. For the value proposition, the company now is able to produce higher volume and more types of products to meet the demand of some big customers. Similarly, the improvement on the range of products and good quality increase the customer satisfaction, which enhance the customer relationships. For the customer segments, before the company produces plastic bags which supply for the supermarkets. Now they find a new segment which has huge demand on hardware, construction, housewares due to Italy government's policies on house constructions. For the key sources to create value, the company said that automation production lines require less labor, which saves the labor cost. Also, the use of advanced robots allow the company use recyclable raw materials, which not only save the cost, but also keep up with the philosophy of environmental protection. For the channels to reach customer and market, the company didn't feel that there is a big change. For the cost structure, the company said that the turnover has been increased continuously these 2 years. They believed this is related with the improvement of the quality of the products and the increasement of production range. For revenue streams, the company didn't see there is a big change. The only revenue is from selling its physical products.

The final question for the company is what it will do in the future to adopt more digital technologies. The company said that although they have tasted the benefits of the digital technologies, but in the short time they don't have plan to adopt more other technologies. The company is satisfied its automation production lines and no plan to invest for a further step. Because they think it will be huge amount of cost. Also, the company bought the automation robots under the European beneficial policies, they received some refund at that time. Now this policy has been finished so they don't want to spend their own money.

Chapter 5. Conclusion and discussion

This part will summarize the findings and answer the research questions.

The first question at the beginning of the thesis is what is the digital technologies adoption situation in manufacturing companies. Two manufacturing companies have been interviewed. The digital technologies that both companies have adopted are cloud computing, cybersecurity, and autonomous robots. Case1 is a bigger company than case 2, so the case1 also adopted internet of things and integrated systems. Case 1 consider to adopt all the rest of digital technologies in the future. Case 2 only considers to adopt big data and integrated system in the future.

The second question is what is the capacity of digital technologies that have been adopted. Apparently case 1 has applied more applications than case 2. Both companies rate the cybersecurity and autonomous robots implementation are more than 80%. Especially case 1 rates 100% on cyber security and case 2 rate 90% on autonomous production.

The third question is how has business model changed before and after adopting the digital technologies. We used business model canvas 9 modules to interview the companies. From the results, we can say that the implementation of automation in production is the most significant factor among all 9 digital technologies and it affects each module in different way. But the common point is that the application of automation in production line allows the company having products with better

quality and help the company to realize mass production, which on one side reduce the cost and on the other side establish a deeper relationship with the customers.

The last question is what they will do in the future to adopt more digital technologies and what are the challenges. The answers from two companies are different which may due to the company size. The case 1 is willing to adopt all the other digital technologies in the future. But they point out that this needs the support from the upper management level's approvement and it can be a long process. They also said that how to integrated all these technologies with a better collaboration is very important. The second case so far does not have plan to implement more technologies because of the investment cost.

Research delimitations and further occurred limitations need to be considered in this research. This research used empirical case studies that allow the writer to interview the workers in the company knowing how they really think and use of the digital technologies. However, the key findings can not be generalized due to the number of cases. Future research may consider how to obtain more respondents while conducting in-depth interviews to get realistic and in-depth information.

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Appendix

Appendix 1. questionnaire on digital technologies

Industria 4.0 e tecnologie abilitanti
(da leggere per completare le prossime sezioni)

- Il concetto di Industria 4.0 sottintende la trasformazione della produzione industriale, avvenuta grazie alla fusione delle tecnologie digitali e di Internet con la manifattura convenzionale.
- L'etichetta "Industria 4.0", indica quindi una strategia industriale e significa produzione industriale digitale ad alto tasso di automazione e connettività.
- Di seguito, vengono riportati i nove pilastri individuati dal governo italiano:

- **manifattura additiva**: stampanti 3D connesse a software di sviluppo digitali;
- **soluzioni manifatturiere avanzate**: robot collaborativi interconnessi e programmabili
  rapidamente;
- **realtà aumentata**: a supporto dei processi produttivi;
- **cloud computing**: consente la gestione di ingenti quantità di dati su sistemi aperti;
- **simulazione**: tra macchine interconnesse al fine di ottimizzare i processi;
- **internet of things industriale**: comunicazione multidirezionale tra processi produttivi e
  prodotti;
- **big data & analytics**: analisi di base dati per conseguire un'ottimizzazione dei prodotti e
  dei processi produttivi;

- **cyber security**: la sicurezza informatica durante le operazioni in rete e su sistemi aperti;
- **integrazione interna ed esterna**: delle informazioni lungo tutta la catena del valore (dal fornitore al consumatore).

– l'obiettivo di questa sezione è comprendere l'adozione o meno delle tecnologie 4.0

1. Quali delle seguenti tecnologie 4.0 vengono adottate all'interno del contesto aziendale? (domanda a risposta multipla)

Tecnologia digitale	**Nessun piano di adozione**	**Considerando di adottare in futuro**	**Già adottato**
Internet of things industriale	☐	☐	☐
Cloud computing	☐	☐	☐
Big data & analytics	☐	☐	☐
Realtà aumentata	☐	☐	☐
Manifattura additiva	☐	☐	☐
Cybersecurity	☐	☐	☐
Integrazione interna ed esterna	☐	☐	☐
Simulazione	☐	☐	☐
Soluzioni manifatturiere avanzate	☐	☐	☐

2.1 Quali sono le applicazioni delle tecnologie già adottate?

2.2 Qual è la percentuale della capacità attuale rispetto alla vostra capacità target? Si prega di compilare la tabella nella prossima pagina.

(Per esempio, l'obiettivo è di realizzare 10 linee in automazione, ora ho realizzato 5 linee, quindi la percentuale è del 50%.)

Tecnologia digitale	Applicazioni (esempio)	Attuale /Obiettivo (%) (esempio)
Soluzioni manifatturiere avanzate	1. Robot di automazione nella linea di produzione	80%
	2. Robot di automazione nella linea di assemblaggio	70%
	3…	…

Si prega di riempire questa tabella:

Tecnologia digitale	Applicazioni	Attuale /Obiettivo (%)
Internet of things industriale	1...	
	2…	
	3…	
Cloud computing	1...	
	2…	
	3…	
Big data & analytics	1...	
	2…	
	3…	
Realtà aumentata	1...	
	2…	
	3…	
Manifattura additiva	1...	
	2…	
	3…	

Cybersecurity	1…	
	2…	
	3…	
Integrazione interna ed esterna	1…	
	2…	
	3…	
Simulazione	1…	
	2…	
	3…	
Soluzioni manifatturiere avanzate	1…	
	2…	
	3…	

3. Quali dei seguenti benefici vengono riscontrati in azienda a seguito dell'adozione delle tecnologie 4.0? (domanda a risposta multipla)

☐ Maggiore disponibilità di dati, da utilizzare sinergicamente

☐ Integrazione delle filiere produttive e delle catene di fornitura/subfornitura

☐ Capacità di posizionarsi nel punto della catena del valore più adeguato da un punto di vista strategico

☐ Time to market più breve (per "time to market" si intende il tempo che intercorre dall'inizio del processo volto allo sviluppo del nuovo prodotto e l'avvio della sua commercializzazione)

☐ Maggiore reattività alle esigenze del mercato

☐ Maggiore flessibilità

☐ Maggiore produttività

☐ Migliore qualità del prodotto realizzato

☐ Minori scarti di produzione

☐ Uso più efficiente delle risorse naturali ed energetiche

☐ Maggiore competitività

☐ Benefici fiscali

☐ Nessun beneficio

☐ Altro: _____

4. Quali sono le sfide dell'adozione delle tecnologie digitali nei processi di produzione nella sua azienda?

_____

Grazie per il suo tempo!

Appendix 12. questionnaire on business model canvas

1. Cosa è cambiato nella sua pratica di gestione dopo l'adozione delle tecnologie digitali? Può parlarne con la seguente struttura?

<table>
<tr>
<td rowspan="2">Partnership chiave:
relazioni con altri soggetti (fornitori e partner). Le tre motivazioni principali per creare partnership sono:
– Ottimizzazione ed economie di scala
– Riduzione del rischio e dell’incertezza
– Acquisizione di particolari risorse e attività

Cambiamento:
_____
____</td>
<td>Attività chiave:
Le attività chiave esse servono a generare il valore offerto, a mantenere le relazioni con i clienti, a raggiungere i mercati e a conseguire dei ricavi. Per esempio, produzione, nuove soluzioni ai problemi di clienti ecc.</td>
<td rowspan="2">Valore Offerto:
L’insieme di prodotti e servizi selezionati e diversificati al fine di soddisfare il bisogno di un determinato segmento di clientela. Per esempio, prodotti e servizi personalizzati, riduzione dei costi ecc.

Cambiamento:
_____
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_____
____</td>
<td>Relazioni con i client:
le relazioni che si instaurano con il cliente.

Cambiaamento:
_____
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_____
____
_____
____</td>
<td rowspan="2">Segmenti di clientela:
L’azienda deve saper decidere a quali segmenti indirizzare la propria offerta e quali invece trascurare. Per esempio, mercato di massa, mercato di massa nicchia ecc.

Cambiamento:
_____
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</tr>
<tr>
<td>Risorse chiave:
Le risorse chiave si riferiscono a quegli elementi che permettono all’impresa di creare valore offerto,</td>
<td>Canali:
I canali attraverso i quali raggiungere il cliente.

Cambiamento:</td>
</tr>
</table>

_____ _____ _____ _____	raggiungere i mercati, mantenere le relazioni con i segmenti di clienti e ottenere dei ricavi. Per esempio, sistemi informativi, intellettuali, macchinari, stabilimenti produttivi, umane ecc. Cambiamento: _____ _____ _____ _____ _____ _____	_____ _____	_____ _____ _____ _____ _____ _____	
La struttura dei costi: la struttura dei costi per le risorse, le attività e i partner chiave. Per esempio, il modello basato sui costi si concentra sulla riduzione dei costi, l'attenzione basata sul valore piuttosto sulla creazione di valore. Cambiamento: _____ _____			**Flussi di ricavi**: I flussi di ricavi costituiscono sostanzialmente il denaro che un'azienda ricava da ciascun segmento di clientele. Per esempio, vendita di prodotti fisici, quote di iscrizione ecc. Cambiamento: _____ _____	

2. Pensate di adottare altre tecnologie digitali in futuro? cosa farete e quali sono le sfide?

_____-