LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
School of Business and Management
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MASTER'S THESIS

INTERNET OF THINGS AS AN ENABLER IN DISRUPTIVE INNOVATION FOR SUSTAINABILITY

Examiner: **D.Sc. (Tech) Ville Ojanen**

Supervisor: **M.Sc. (Tech) Nina Tura**

Mina Nasiri

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ABSTRACT

Author: Mina Nasiri

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Examiner: D.Sc. (Tech) Ville Ojanen

Supervisor: M.Sc. (Tech) Nina Tura

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This research concerns the way of facilitating the occurrence of disruptive innovation for sustainability by Internet of Things (IOT) solutions. One of the main objectives of this thesis is to find connections between IOT solutions, disruptive innovation, and sustainability. Moreover, this thesis critically review the research related to this topic to reveal future research areas in this field. In order to achieve the objectives of this thesis, research has been conducted towards three different aspects. The first aspect is to find the challenges of disruptive innovation for sustainability. The second one is to seek the value creation by IOT solutions in social, economic, and environmental dimensions of sustainability. The last aspect is to find the way of promoting the performance of circular economy by IOT technology. Finally, this thesis has been complemented with real-world perspectives from the conducted expert interview. The previous research studies have provided a valuable insight into the knowledge of IOT. However, according to the knowledge of the author, most of these studies have focused on the application of IOT in different industries, and no studies have inclusively examined the impact of IOT in each dimension of sustainability. The results show that IOT opens up a new room for revolution by embedded RFID tags, sensors, and actuators in objects. The solutions provided by IOT offer a possibility to economic, industrial, and business development. These solutions improve not only the social sustainability but also environmental sustainability because of the provision of peoples' facilities to have a safe, secure, and eco-friendly life.

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Mina Nasiri,

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LIST OF SYMBOLS AND ABBREVIATIONS

API	Application Programming Interfaces
CE	Circular Economy
EPC	Electronic Product Code
EPR	Extended Produces Responsibility
ETC	Electronic Toll Collection
ETSI	European Telecommunication Standards Institute
GSCM	Green Supply Chain Management
GSM	Global System for Mobile Communication
ICT	Information and Communication Technology
IDC	International Data Corporation
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IIOT	Industrial Internet of Things
IOT	Internet of Things
IP	Internet Protocol
ITU	International Telecommunication Union
LCA	Life Cycle Assessment
MIT	Massachusetts Institute of Technology
P2P	Peer to Peer
RFA	Rainforest Alliance
RFID	Radio Frequency Identification
3R principle	Reduction, Reuse, Recycle
SEAM	Sustainable Energy Asset Management
SOI	Sustainability-Oriented Innovation
SOM	Sustainable Operation Management
SUP	Suspected Unapproved Parts
TCP	Transmission Control Protocol
VOIP	Voice Over Internet Protocol
WCED	World Commission on Environment and Development

1 INTRODUCTION

This chapter starts with background and motivations of this thesis. Then it continues with objectives and research methodology, and finalizes with the structure of the thesis.

1.1 Background and Motivations

Recently, sustainability has turned to hot topic amongst both academics and practitioners because of its reliance on economic aims of companies with less negative impact on the environment. In addition to this, awareness of the society about environmental issues attracts people to purchase green products. Therefore, sustainability, defined as "Economic development that meets the needs of the present generation without compromising the ability of future generation to meet their own needs" (WCED, 1987), has become a core challenge for organizations to produce green products (Gunasekaran et al., 2014). Moreover, Circular Economy (CE) with the aim of reduction in a waste creation and avoid pollution by design, contributes substantially in a positive way. The aim is to make a balance between all the elements based on environmental, political, and economic, as well as business aspects (Ghisellini et al., 2016).

An innovative approach is needed in order to achieve sustainability in business. The theory of disruptive innovation has become one of the tough subjects for both academia and practices (Reinhardt & Gurtner, 2015). The reason is the shift in the procedures of creating products or services. This new process changes the market performance from customer expectations and competition to new performance attributes in a way that market doesn't expect (Keller & Hüsig, 2009).

Internet of Things (IOT) is the modern paradigm that spread out quickly in the scenario of novel wireless telecommunication. The main thought of IOT is to have interaction with each other, and cooperate fully with neighbors in order to reach goals by the use of modern wireless telecommunications such as Radio Frequency Identification (RFID), sensors, tags, actuators, mobile phones, and et cetera (Giusto et al., 2010). The importance of this paradigm is related to the impacts of this technology in everyday life. These impacts can be found both on different working, as well as domestic chores clearly. E-health, education, logistics,

process management, automation, manufacturing, and intelligent transportation are among the subjects which can reap the benefits of IOT (Atzori et al., 2010).

According to the knowledge of the author, there is a lack of studies which integrate Sustainability, Disruptive Innovation, and IOT altogether. Research about these issues helps to provide enormous value for both individuals and companies. Moreover, the vast numbers of studies have conducted on the application of IOT in different fields, but it is a lack of research on the method of providing value by IOT technology in each dimension of sustainability. Additionally, conducting research on challenges including enablers or barriers of disruptive innovation for sustainability, can be named as an important topic with many rooms for improvement in business. It makes a revolution in different industries which lead to competitive advantages for companies and improve the quality of life for individuals. Finally, according to the knowledge of the author, investigation on the IOT as enablers in disruptive innovation for sustainability can be described as the tough and challenging topic, because of the revolution that it provides in different fields. For example, providing rooms heating and lighting according to users' preferences, weather, and the time of the day, as well as preventing from a domestic accident by the use of an intelligent alarm, can be named as few examples of IOT which can provide sustainability for organizations (Buckl et al., 2009). Utilization of IOT in different fields results in saving energy, cutting costs, fewer fuels, waste reduction, and time saving which all of them can be named as the influential factors in sustainability. Therefore, in this research, IOT is seen as an enabler for disruptive innovation that can create and enhance sustainability in organizations (MacArthur, 2012).

1.2 Objectives

One of the essential goals of this state-of-the-art literature review is to critically review the research related to this topic and reveal future research areas in this field. The main focus of this research is to seek the relationships between IOT solutions, disruptive innovation, and sustainability and find the answer to the question of *how can IOT facilitate the occurrence of disruptive innovations for sustainability?* In order to reach the final goal, answering the following questions is necessary. *I. What are the challenges of disruptive innovation for sustainability? II. How can IOT provide value in each dimension of sustainability? III. How can IOT enhance the performance of CE for disruptive changes?* Therefore, in this literature

review, combining the perspectives of sustainability, disruptive innovation, IOT, and CE is required. This will help to not only find the relations between mentioned knowledge better but also reveal the future research in this research area. Therefore, before achieving the final goal, investigation on related concept separately and collecting useful information to find the best solutions for mentioned research questions, are required.

1.3 Research Methodology

The method of this research mainly is based on an extensive literature review to find state-of-the-art connections between IOT solutions and disruptive innovation for sustainability. It also focuses on IOT enabling disruptive innovation for sustainability. Both primary and secondary data are used in this research. The primary data is gathered by using reports and literature examples of significant innovations for sustainability by connections with IOT. The words such as disruptive innovation, sustainability, Internet of Things, sustainable business, and circular economy have been used as the keywords in order to find useful information. Furthermore, Nelli portal/Lut, Google and Google scholars have been utilized as the main search engines in this research. The secondary data is based on an interview with an expert of SITRA. SITRA is the public fund with the aim of building a successful Finland for tomorrow. They are forward thinking and anticipate social change as well as its effect on people. The SITRA's activities promote new operating models and stimulate businesses that aim at sustainable well-being (SITRA, 2016).

1.4 Structure of Thesis

This thesis divides into seven chapters which start with **Introduction** and encompass with four different parts including Background and Motivation, Objectives, Research Methodology as well as Structure of Thesis.

Chapter 2 is **Business Sustainability** which divides into two parts. The first part is about sustainability with the main focus on the concept and its dimensions, while the second part is about sustainable development with the main concentration on the evolution of sustainable development business as well as the role of CE in sustainable development.

Chapter 3 is **Innovation for Sustainability**. This chapter consists of two different parts. The first part is about the concept of innovation which encompasses sustaining innovation and disruptive innovation, while the second part is about challenges in disruptive innovation for sustainability which answer to the first subquestion, *what are the challenges for disruptive innovation for sustainability?*

Chapter 4 is about **IOT as Expression of Disruptive Innovation**. This chapter is about IOT which describes about the concept of IOT, its definitions from different perspectives, Elements, Architectures Features and Platform, enabling technologies and challenges as well as its application in different field of industry.

Chapter 5 is about **IOT in Disruptive Innovation for Sustainability**. This chapter will answer to the second and third sub-questions: II. *How can IOT enhance the performance of CE for disruptive changes?* And III. *How can IOT enhance the performance of CE for disruptive changes?* The first part of this chapter is about the value creation for sustainability and will study the impact of IOT in each dimension of sustainability, whilst the second part is related to the improvement which IOT can provide in CE.

Chapter 6 is about the **Practical Perspective**. This chapter encompasses two parts which the first one is about SITRA's background and its field of activities while the information of the second part is gathered through a semi-structured interview with one of the members of the SITRA.

Chapter 7 is **Discussion**. This chapter divides into two parts. The first part is the results which draw a comparison between findings from literature review among different scientific articles and SITRA's perspective which gathered through a semi-structured interview. The second part is further research, limitations, and implications of this study.

Chapter 8 is **Conclusion** which finalizes this thesis with the findings.

2 BUSINESS SUSTAINABILITY

The idea of business sustainability has been spread out broadly during the last two decades which moves constantly toward extra, as well as far-reaching attempts (Encalada & Caceres, 2012). According to Deloitte & Touche (1992), the term business sustainability, described as "adopting business strategies and activities that meet the needs of enterprise and its stakeholders today, while protecting, sustaining, and enhancing the human and natural resources that will be needed in the future" (Deloitte & Touche, 1992).

Sustainability in business is composed of maintaining and improving economic development, stakeholder value, reputation, and considerable prestige while providing enhancement to the level of product or service quality, as well as customer relationship. Additionally, sustainability in business leads to producing sustainable jobs, dealing with under-served requirements, as well as beginning and continuing ethical business practices (Szekely & Knirsch, 2005). On the other side, business sustainability includes the integration of social equity, economic efficiency, and environmental performance as the objectives of sustainable development into a company's operational practices. Therefore, an optimum decision can be achieved with the consideration of social, economic, and environmental results (Labuschagne et al., 2005).

Many drivers exist in order to achieve sustainability in business. Managerial, operational, and economic factors define as the internal factors for sustainability in business, while market factors, governmental factors, as well as stakeholder expectations, describe as the external factors. All these factors need some activities for adapting to sustainable approaches, shown in *Table 1* (Szekely & Knirsch, 2005).

Table 1: Factors for determination of successful sustainability in the company (Szekely & Knirsch, 2005)

Internal Factors			External Factors		
Managerial factors	**Operational factors**	**Economic factors**	**Market factors**	**Government factors**	**Stakeholder expectations**
• Complete assessment of internal organizational structures and management processes. • Development of incentive mechanisms in order to improve the sustainability initiatives and sustainable performance of the organization. • Recognition of potential business opportunities at an early stage. • Identification of management failures, potential threats, and emerging risks. • Better management of risk and reduce risk levels. • Improvement in the safety of workers, the quality of labor recruitment and retention.	• Recognition of environmental issues. • Reducing environmental footprint. • Minimization of material inputs. • Acquiring energy efficiency.	• New market opportunities. • Cost savings. • Technological innovation.	• Product differentiation. • Customer's value. • Accessibility to new markets. • Industry competition. • More competitive labor markets. • Develop company reputation. • Ranking agencies. • Socially-oriented investors. • Improve customer interest in ethical and socially responsible business behavior.	• The increase in regulatory intervention. • Operating licenses.	• Complete transparency and accessibility to information. • Internalize the negative externalities like pollution and waste. • Demands for lower material usage. • Adoption of international labor codes (human rights groups). • Clear reporting (investors and authorities).

The sustainability performance in companies can be measured from different perspectives. Simplicity, understandable, comparable, simple reproduction, complementary to regulatory programs, economical data collection, scalable, usefulness, safe and secure of companies' information, are among the measurement factors for sustainability performance. On the other side, Leadership and vision, flexibility to change, and openness for engagement are three critical factors for successful sustainability performance. Term "Leadership" defines as the achievement of the management commitment, as well as enhances a system of incentives for leaders to encourage the adaptation of sustainability. Moreover, it has the ability to communicate with different members of society easily and answer to shifts in a flexible way (Szekely & Knirsch, 2005).

To conclude, the principles of the sustainability provide opportunities for the business to lower the unnecessary requirements, prevent waste creation, enhance materials, energy efficiency, innovate novel things, and acquire functional permits from local communities, as well as eco-friendly products and services. Therefore, dealing with sustainability principles leads to more profitable business, and sustains business activities during a long period of time (Szekely & Knirsch, 2005).

2.1 Sustainability

Sustainability has become the main concern due to environmental issues, lack of natural energy resources, industrial pollution and deficiency of raw materials nowadays (Gunasekaran et al., 2014). The importance of sustainability has been described in different industries regardless of the size of the companies from the ones which have high impacts on the environment including automotive and food companies to small and medium size enterprises such as commerce and tourism. General Electric, Toyota, IBM, Shell and Walmart are among the international companies which their activities in sustainability distributed around the world broadly (Encalada & Caceres, 2012).

Hannß Carl von Carlowitz introduced the term "Sustainability" for the first time in 1713 with the concentration of the limited amount of wood in the forest (Weidinger et al., 2014). Sustainability has been defined semantically as "quality that permits to preserve, to keep, to maintain something: when something is sustainable, it is able to be kept" (Garetti & Taisch,

2012). The previous definition of this word was mainly about the environment in the past which sustainability defined as “The quality to sustain the environment” (Garetti & Taisch, 2012). In 1987, the concept of sustainability formulated according to the Brundtland report when describing sustainable development as “a way for improving the quality of life and well-being for the present and future generations” (Garetti & Taisch, 2012).

The main aim of the sustainability is in creating production process in a way that doesn’t harm the environment, decreases expenses of natural energy resources, and has efficient use of the human resource (Molamohamadi & Ismail, 2013). Consequently, Szekely & Knirsch (2005) define sustainability through creating an appropriate balance between social, environmental, and economic goals in society (Szekely & Knirsch, 2005). Additionally, taking actions for sustainability result in cost reduction which is achieved by using alternative materials, less packaging, lower energy usage in production, reductions in material storage and waste disposal. Apart from cost reduction via advanced sustainability, these activities provide positive feedback for consumers due to its product improvement and savings which provided for customers (Epstein & Roy, 2001).

Literature review on sustainability shows that there are two different strategic frameworks for sustainability. The first strategy framework has been stated by Colbert & Kuruc, (2007), it is the method of interpretation for the term sustainability according to “Intent” and “Alignment” as the two dimensions of sustainability. Dimensions of intent consider the aims and objectives that admitted in a specific idea, while the dimensions of alignment concentrate on the achievements of the supporting attributes with the aim of understanding the intent of a specific idea. The second strategy, proposed by Nidumolu et al., (2009), has defined as the complementary for the first strategy. Five phases including viewing compliance as the opportunity, making value chains sustainable, designing sustainable products and services, developing new business models, and creating next practice platforms have been defined as the main practices in this strategy (Colbert & Kuruc, 2007; Encalada & Caceres, 2012).

Environmental, social, and economic have defined as three different dimensions of sustainability which called “Triple bottom line” as shown in *Figure 1* (Molamohamadi & Ismail, 2013).

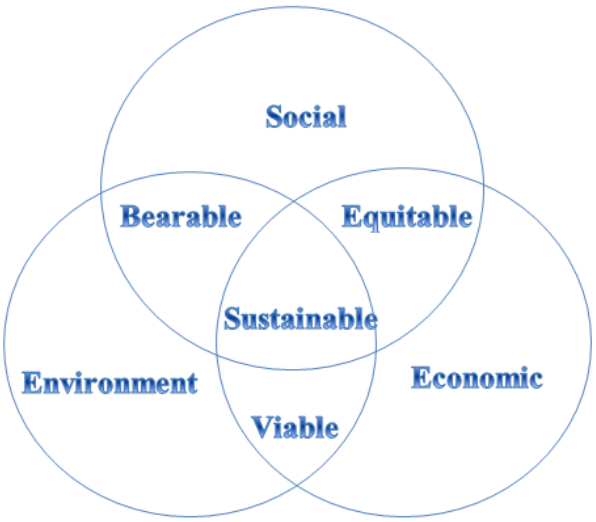

Figure 1: Three pillars of sustainability (Molamohamadi & Ismail, 2013)

The origin of the environmental dimension of sustainability comes from the increase in the environmental issues during the time. Since the 1980s, the environmental sustainability has become a central problem which encompasses both local and universal concerns from acid rain to global warming. Additionally, some other issues such as drought, sea level increase, as well as habitat destruction are among the environmental issues which need more attention (Choi & Ng, 2011).

In the domain of environmental dimension, four practices define for sustainability. *Figure 2* shows value improvement through products focus can be reached by developing product or service solutions with neutral environmental impact. For instance, developing energy saving technologies with a high-value proposition for customers or providing different fuel option for vehicles. Value improvement through process focus relies on creating value for customers by sustainable methods in production process like organic manufacturing. Another action is cost decrease through product focus. Remanufacturing can be named as an efficient method for cost cutting and be sustainable. Companies can get more values by reuse of material and component. For example, XEROX uses copy machines which facilitate remanufacturing that results in energy saving and waste reduction. The last action is about cost decrease through process focus. This action concentrates on the manufacturing process that reduces cost in a way that is efficient. Lean manufacturing can be named as an example of this technique as well (Wiktorsson et al., 2008).

	Value Improvement	Cost Decrease
Product Factors	"PRIUS" Material and Technology Selection Improving Customer Value	"XEROX" Material and Component reuse Remanufacturing
Process Factors	"ORGANIC AGRICULTURE" Selling by sustainable processes	"SUSTAINABLE LEAN" Waste reduction

Figure 2: Actions for environmental sustainability (Wiktorsson et al., 2008)

The social dimension of sustainability goes back to the forestry in the middle age; the time that lumber used as the main source of economic processes including constructing material and energy sources. The population increase is a cause for concern about an economic and social crisis which led to defining sustainable forestry. Therefore, sustainable forestry reveals the importance of sustainability for a continued survival of societies for a long period of time (Zink, 2014).

The main concern of the social dimension of the sustainability is about the well-being of the societies and people based on a non-economic type of wealth. Providing balance between the personal and societal needs and the capacity of the nature to support human life and environment can be named as sustainability issue in this dimension. In 1999, the survey showed that approximately 70 percent of the people who participated in the survey had a desire to the contribution of the broader range of social objectives (Choi & Ng, 2011).

The economic dimension of the sustainability has turned to new attention throughout the world in 2008 with the economic collapse of Wall Street financial institutions. The universal economic recession has become the main concern of the consumers and people because of the fear of prevalent unemployed, lack of security as well as financial risk to governments and public programs. Two different aspects define the economic dimension of sustainability by Sheth et al., (2011). The first aspect is about ordinary financial performance including cut costs. The second one is economic interests of external stakeholders including a wide range

of growth in economic well-being as well as living standard. Sheth et al., (2011) have been included these two aspects in the framework for consumer-centric sustainability. The importance of this approach has been shown in the groups of companies based on the consideration not only of the financial performance of the companies but also on the connections to the community (Choi & Ng, 2011; Sheth et al., 2011).

Integration of environmental, social, and economic with the aim of creating a balance between them is the main approach to sustainability. Sustainable society achieves with the help of companies, by the use of creating innovative products and services based on not only economic and environmental attraction, but also satisfying social requirements. Additionally, there is a need to economic, environmental, and social indices need to recognize new opportunities and risks for the companies before its occurrence. For instance, having knowledge about energy consumption and the kind of fuel that the company used will enable to recognize the future risks of carbon emission (Szekely & Knirsch, 2005).

In recent years, researchers have been trying to find whether both environmental and social threats can be solved by technologies. Therefore, technology is an important factor for improving sustainable society. Consequently, According to this fact that technology and education cannot separate from each other, Garetti & Taisch, (2012) identify technology and education as the two enablers for sustainability framework (Molamohamadi & Ismail, 2013; Garetti & Taisch, 2012) (See *Figure 3*).

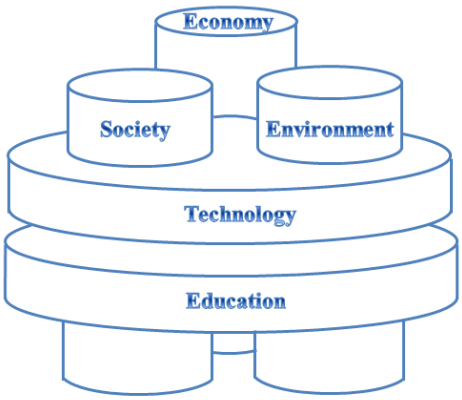

Figure 3: Sustainable manufacturing framework (Molamohamadi & Ismail, 2013)

Garetti & Taisch (2012) enhance the sustainable manufacturing by adding two new dimensions including ethics and accountability to the previous one. The new framework for sustainable manufacturing development has been proposed by Molamohamadi & Ismail, (2013) as shown in *Figure 4* (Garetti & Taisch, 2012). Therefore, According to Wiktorsson et al. (2008), sustainability can be grouped as an order winning or an order qualifying objects relying on technology, market, and society (Wiktorsson et al., 2008).

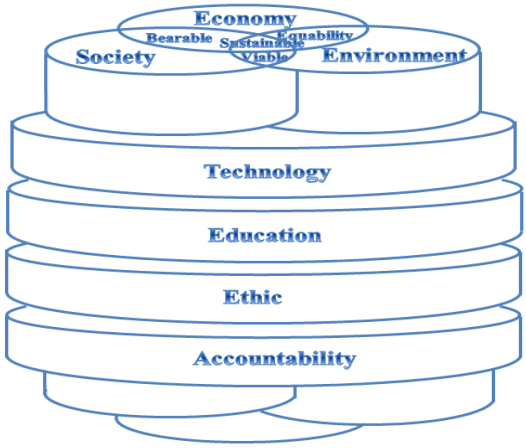

Figure 4: New proposed framework for sustainable manufacturing (Wiktorsson et al., 2008)

As a result, a dramatic ecological shift, globalization, wrong perception about shareholder value concept, financial market crisis as well as increasing demand for corporate social responsibility, are among the reasons for growing interests in sustainability (Zink, 2014).

2.2 Sustainable Development

Sustainable development creates a vast number of competitive advantages in organizations. Efficient use of human resource and retention of the workforce, cost savings, waste reduction, and energy preservation, are among the advantages of sustainability, while companies can enhance their official connections with stakeholders and corporate reputation with utilizing sustainability in their business (Molamohamadi & Ismail, 2013).Two different definitions have been provided by the Brundtland report in 1987. The first one is

"Sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Weidinger et al., 2014). The second one is "In essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development as well as institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations" (Weidinger et al., 2014). Moreover, the vast numbers of definitions have been proposed in academic discussions as well as business fields which concentrate more on humanity, ethical as well as a clear manner of conducting business (Garetti & Taisch, 2012).

According to Zink et al., (2008), sustainable development process depends on three fundamental ideas. The first idea is to concentrate on human requirements in a way that is environmental friendly. The next idea is the definition of sustainable development created by WCED in 1987. The last idea is about creating a balance between social, economic, and environmental aims as three dimensions of sustainable development (Zink, 2014; Zink et al., 2008).

Steady attempts, investments, and adaptation are required for adopting a sustainability approach. It needs not only involvement of external and internal stakeholders, but also initiatives of different sectors and multiple stakeholders. This endorses the procedure of learning and enhances credibility, commitment, and innovation in companies (Szekely & Knirsch, 2005).

2.2.1 Evolution of Sustainable Development Business

International Energy Agency (IEA) estimates that humanity will witness of 53% increase in global energy consumption by 2030. Therefore, global warming, depletion of the source of energy, change in the balance of ecosystem lead to employ strategies modified for sustainable development (BoudgheneStambouli et al., 2014).

The importance of sustainability in both society and the industrial world cannot be neglected due to its ability for providing competitive advantages and profitability for the companies (Bourhis et al., 2013). For example, Ford Motor Company has established the absolute necessity of additional growth in the fuel efficiency of its vehicles because of the drastic

climate change issues recently. The Ford's senior managers believe that continuing success in business without consideration of climate change in market strategy and comprehensive business, is impossible. The managers have faced challenges to create strategies with the aim of making a balance between environmental, social, and economic requirements according to both company and societies preferences (Epstein & Roy, 2001).

Different practices have implemented to develop sustainability in the manufacturing process. This development has evolved from the traditional manufacturing with the main concern on cost, quality, delivery and flexibility in production to sustainable manufacturing with the aim of providing an appropriate balance between three dimensions of sustainability and answer shareholders' requests as well as acquire competitive benefits (Dubey et al., 2016). Sustainable development provides an opportunity to improve the standards of the human life level by enhancing the available natural resources and ecosystem for the next generation. Moreover, the main concerns for manufacturing industries are related to economic, social, environmental, and technological challenges (Kumaraguru et al., 2014).

Sustainable manufacturing has been defined as the part of the sustainable development with the aim of providing a balance between economic, social and environmental dimensions (Kumaraguru et al., 2014). In 2007 US department of Commerce defined sustainable manufacturing as "The production of products in a way that has minimum negative effects on the environment as well as preserve energy and natural resources with safe and economical methods for employers, societies, and customers" (Dubey et al., 2016).

Use of environmental and social accounting tools for representation of "external" effect of industrial activities are prevailing recently for production industries. These tools are environmental cost accounting, environmental liabilities, environmental investment appraisal, life cycle assessment (LCA), and life cycle costing within an environmental economics framework. Among the mentioned tools, LCA can be named as the comprehensive information in all production stages (Kumaraguru et al., 2014).

LCA and social audits are named as the influential instruments with the aim of providing opportunities for the organizations to understand both social and environmental features of their business and enhance their performance by the use of representing helpful information. These tools enable managers to recognize the specific influential aspect of business activities on sustainability and result in both corporate sustainability and enhanced sustainability in

business, based on companies' preferences and area of concern. For instance, Grundfos is a leading company in Denmark which focuses on the production of pumps and development of pumping systems throughout the world. According to the results that have been achieved by LCA, Grundfos defines energy usage as the main issues and has concentrated on the environmental initiatives by promoting the number of eco-efficient products. This company sets environmental goals in the area of energy efficiency, material usage as well as disposal of its products (Epstein & Roy, 2001).

According to Linton et al., (2007), Sustainable Operation Management (SOM) is planning, coordination, and control of a system that generates or improves customer values in an economical way with real consideration for natural resources and environment (Linton et al., 2007). In other words, it focuses on the idea that the management of operations should consider both economic interests and environmental issues such as reduction of carbon footprint, a cost of reverse logistics, remanufacturing, and Green Supply Chain Management (GSCM) as the companies' objects. The decisions which related to SOM can be grouped into two parts. One is "System design" which concentrates on product and process design, location planning and analysis as well as capacity planning. Another part is "System operations" that are related to the procurement, production, and logistics (Gunasekaran et al., 2014).

Procurement or purchasing is a component of supply chain management, which turns to the essential subject due to its significant effects on social, economic, and environmental performance. For instance, transportation and its possible future effects on carbon footprint as well as the cost of energy could affect companies' sustainability (Gunasekaran et al., 2014).

Planning, scheduling, and quality control can be named as the components of production. Environmental management which encompasses remanufacturing has turned to a vital issue for different groups of stakeholders such as end users, industrial customers, suppliers, and financial parties. The term "Remanufacturing" describes as the process of recovering, producing, and selling of the used products as the new products (Gunasekaran et al., 2014).

2.2.2 The Role of Circular Economy in Sustainable Development

Circular Economy (CE) can be named as a sustainable development approach with the aim of addressing urgent environmental issues as well as resource scarcity (Heshmati, 2015). During the last decade, the development of CE has been attracted more attention around the world in order to find a better alternative for the conventional economic model which based on "take, make and dispose". Therefore, CE has been introduced as a novel business model which result in sustainable development as well as pleasant society. Providing balance between economic, environmental, social, and technological aspects of the sustainability as well as considering integration between these dimensions of sustainability for investigated economy, sectors or individual industrial procedures, can be defined as requirements for sustainable development (Ghisellini et al., 2016).

The main aim of CE is to improve the use and access of the resources based on the implementation of innovative methods or business models for greener economy while considering advanced well-being as well as high quality during generations. In addition to this, CE has the ability to create a radical design and provide opportunities to improve sustainability as well as advanced well-being with considering less amount of material, energy, and environmental charges (Ghisellini et al., 2016).

On the other side, CE is defined as an ecological economy concept which concentrates on three dimensions of sustainability: economic, social, and environmental. In terms of economic aspect, the main concern is to improve the resource allocation, resource consumption, and productivity in an efficient way which leads to higher competitive advantages in both local and domestic scale. With regard to environmental aspect, redesign of the industrial structure, based on eco-friendly methods, is required in order to decrease the negative issues. The social aspect of this method provides employment opportunities, equal economic development distribution as well as enhancement in societies' overall well-beings (Su et al., 2013).

The knowledge of CE can be found in different schools of thoughts. From the economics perspective CE system, introduced by Pearce & Turner, (1990), is based on the previous studies of an ecological economist called (Boulding, 1966). According to Boulding, (1966), a circular system is necessary strategy for maintaining the sustainability of people's life throughout the world (Boulding, 1966). Furthermore, Boulding, (1966) in his essay of "The

Economics of Coming Spaceship Earth" has stated that economy and environment portrait by a closed loop relationship where everything is the input of everything else (Heshmati, 2015). Therefore, Pearce & Turner (1990) describe the needs for change from open-ended economic system to the CE system based on the first law of thermodynamics (Pearce & Turner, 1990). According to this law, the total energy of an isolated system remains constants and does not have the ability to destroy and creates extra energy while these energies can transform from one type to another type. It means that in order to tackle the resource scarcity and environmental issues, circular material flows in the economy are needed (Su et al., 2013).These authors have common perspective that provision of resources, life support system as well as a sink for waste and toxic emission are among the three recognized economic functions of the environment which should have a price. Regulations, economic tools or voluntary measures can use as the combined strategy to embed these three economic functions into the service or products' prices. The aim of this action is to encourage people for better consumption and preservation of the virgin resources while reducing environmental issues as well as make enhancement to shift to CE patterns (Ghisellini et al., 2016).

From the viewpoint of General system theory and Industrial ecology, CE has been introduced through three main actions which named 3R principles including Reduction, Reuse, and Recycle (Ghisellini et al., 2016). These principles explain CE in a way that the whole number of materials are recycled as well as renewable energies utilized while the supportive activities with the aim of value creation for improvement in the ecosystem, resources, and human health are required (Heshmati, 2015). CE has been described by the promotion of Chinese' law as "a generic term for the reducing, reusing and recycling activities conducted in the process of production, circulation and consumption" (CCICED, 2008). This definition is the contradictory statement according to China's pattern of behavior in continued development of production as well as consumption within a local scale. On the other hand, other countries including Europe, Japan, USA, Korea as well as Vietnam concentrate on 3R principles based on waste management policies. The main aim of CE is creating the national policies for prevention of landfill, production of resources, toxic emission cuts as well as treatment methods for management of hazardous wastes based on material circulations while considering trade-offs between policies as well as integrated

political approaches like CE as the continues activities for tackling with environmental issues (Ghisellini et al., 2016).

Implementation of CE requires consideration of 3R principles not only in production phase but also during consumption. “Reduction” has been created through reduction of input of primary energy as well as raw materials via enhancement of production method efficiently. The concept of “Reuse” in CE refers to the utilization of by-products as well as wastes for one company as a resource for the other companies or industries. Additionally, it means utilization of products as maximum capacity accompanied with repeated maintenance as well as reclamation to extend the resistance of the products. “Recycling” refers to the procedure of transforming recyclable materials to the new products which lead to a reduction in the level of raw material consumption. These three principles can be named as the part of the entire production process which leads to CE (Su et al., 2013).

From the viewpoint of Ellen MacArthur Foundation Report (Ghisellini et al., 2016), the 3R principles have the possibility to integrate with the help of three various extra principles. The first principle is a suitable design which emphasizes the key role of design stage in order to figure out appropriate solutions to avoid the waste discharge in landfills. Reclassification of materials into two parts such as “Technical”, including metals and plastics design in a way that can reuse at the end of the life cycle and “Nutrients”, meaning the materials that are not hazardous and can come back to ecology safety. The third one is renewability which introduces renewable energies as the central energy source for CE in order to minimize the consumption of fossil fuels (Ghisellini et al., 2016).

Quick degeneration of the environment throughout world results in needs for growth in policies to minimize the negative impacts of usage and production of products or services. Various rules and actions have been implemented by different countries to establish the concept of CE (Heshmati, 2015). Germany was the first country in Europe which emerge the concept of CE with “Waste Disposal Act” in 1976 and enhance this knowledge at European Community level CE with the help of Waste Directive 2008/98/EC as well as CE Package (Ghisellini et al., 2016). Additionally, the law of “Closed Substance Cycle and Waste Management Act” has been enacted in 1996 which leads to the creation of a framework to implement closed cycle waste management while ensuring environmentally waste disposal as well as assimilative waste capacity (Heshmati, 2015; Su et al., 2013). In

Japan, CE introduced in 1991 after implementing the law for “Effective Utilization of Recyclables” while the government has been implemented a thorough legal framework for achieving a society based on recycling which became obligatory activities in 2002 (Ghisellini et al., 2016; Heshmati, 2015). The activity of these two countries has common characteristics which both of them try to stop additional environmental degeneration as well as to preserve scarce resources via effective waste management techniques particularly integrated solid waste management (Su et al., 2013).

China has the different policies in compared to Germany and Japan which decided to introduce CE in small scale at the beginning via the numbers of pilot cases and then evaluating its performance in large scale (Heshmati, 2015). The concept of CE started in the United States with one rule as “Resource Conservation and Recovery Act” in 1976 and the other rule as “Pollution Prevention” in 1990 while adopting to a solid waste management hierarchy in 1980. At the top of the hierarchy was reduction and reuse actions which were among important activities. In addition to this, some activities such as making a plan for used oil, decreasing content laws, recycling beverage containers as well as green labeling can name as the activities that the United States have done in this regard. Although the US has implemented many different activities in this regard, it still misses the lack of related federal policy for CE initiatives (Ghisellini et al., 2016).

Improvement in 3R principles of CE has been seen in a wide range in Asia especially in industrial ecology. The main concentration of industrial ecology is about the advantages of recycling by-products as well as residual waste materials. Consequently, CE tries to enhance reduction of resource usage as well as adapting to cleaner technologies (Andersen, 2007). For instance Korea and Vietnam can be named as the representative countries in Asia which enhanced 3R principles of CE. Korea has been introduced “Waste Management Act” in 2007 as well as “Act on Promotion of Resource Saving and Recycling” in 2008. These two actions have been introduced as the primary activities for material reuse, implementation of fee system for waste treatment, creating laws about the consumption methods of one-way packaging and goods, the policy for waste cuts in food section as well as Extended Produces Responsibility (EPR). In Vietnam, the “Environmental Protection Law” has been promoted in 2005 while achieving the local policy on integrated solid management has been set the target in 2025 and 2050. On the other hand, both Australia and New Zealand can be named

as the countries which currently assessing and fasten the procedures for CE (Ghisellini et al., 2016).

As conclusion, CE has many advantages not only for society but also for the economy in industrial ecology. The advantages that this technology provided is not limited to decreasing usage of an environment including a place for residuals, but it contains making a reduction in the usage of virgin materials for economic activities. Moreover, CE gradually has been a witness of the shifts from limited waste recycling to the wide control in achievements of efficiency in all phases of circular material flows such as production, distribution, and use. Therefore, apart from resource scarcity and waste issues, energy efficiency and preservation which were the initial concern of CE, CE covers more issues such as land management and solid protection as well as water resource management issues. Consequently, all these values created by CE, lead to sustainability in various fields (Su et al., 2013).

3 INNOVATION FOR SUSTAINABILITY

Innovation and Sustainability can name as the two repeated word in business these days. Concentration on one of these words provides secure development and competitive advantages for companies. Therefore, a combination of these two words turns to an important topic which might lead to the real winner in business for a long period of time (Szekely & Strebel, 2013).

Transform the way of thinking from sustainability, as the clearly separate elements of compliance, risk, as well as brand management, into the significant way of cost reduction through benefits in efficiency and providing opportunities for absorbing high skilled people, increasing revenue and market share as well as creating successful innovation is the main progress in sustainable management practices literature. On the other side, innovations do not limit in making transformations in business, production procedures, and operating process but include changing a business model, the way of thinking as well as the overall system. Innovation for sustainability means the development of new products, business, and services based on social, economic as well as environmental dimensions of sustainability. Moreover, these terms such as eco-innovation, environmental innovation, and green innovation have been introduced as the concept that define sustainable innovation (Szekely & Strebel, 2013).

According to Arnold & Hockerts (2011), sustainability-oriented innovation (SOI) defines as “realized ideas that improve environmental and/or social performance compared with the current situation” (Arnold & Hockerts, 2011). Utilization of resource inputs efficiently, the creation of advanced products or services as well as novel business model structure can be named as the main concern of SOI. SOI for new products or services looks for market differentiation with development in environmental and social performance more that the existing situation. Different concepts such as green product innovation, eco-innovation, and sustainability-driven innovation have been defined in this regard (Kennedy et al., 2016).

SOI considers with two different dimensions. The first one is novelty assessment which relies on the type of innovation while the second one is related to sustainability performance

of the product innovations. Moreover, the factors for successfulness in SOI classify into four different groups. These factors are the following (Kennedy et al., 2016):

- Having knowledge about Market, law and legislation including green purchasing and competitor monitoring.
- Inter-functional cooperation among internal part and with external stakeholders.
- Innovation-oriented learning such as improvement in SOI competencies and capabilities for serious reflection.
- Research and Development investment in SOI infrastructure, human resource and technology.

3.1 The Concept of Innovation

With the change of marketplaces to be more dynamic, motivations for innovation, the management as well as the procedures of innovation has been increased. Therefore, innovation requires companies to satisfy the changes in the customers' lifestyle and demands and use the opportunities that proposed by technology, marketplace transformation, structures and dynamics (Baregheh et al., 2009). Innovations can provide business advantages for company and have become a vital factor for companies' survival and successfulness. Therefore, innovation is a complex process and many companies try to push themselves to innovate because of the steady economic growth. (Murray et al., 2016).

The widespread type of innovation is based on novel products, materials, novel procedures and new services as well as new organizational frames. All these kinds of innovations provide an opportunity to utilize innovation in many different fields of studies and industries. Few numbers of examples have been stated in order to identify the diversity of innovation in different fields (Baregheh et al., 2009). According to Thompson (1965) the term innovation defined as "The generation, acceptance and implementation of new ideas, processes products or services" (Thompson, 1965). West & Anderson (1996) have been stated the same definition and repeated in 2008 by Wong et al., (2009) which describe innovation as "The effective application of processes and products new to the organization and designed to benefit it and its stakeholders" (West & Anderson, 1996; Wong et al., 2009).

On the other side, different definition based on different viewpoints with consideration of various forms of innovation has been proposed by Kimberly, (1981) which defines innovation as “There are three stages of innovation: innovation as a process, innovation as a discrete item including, products, programs or services; and innovation as an attribute of organizations” (Kimberly, 1981). The other definition concentrates on the degree of newness. For instance, Van de Ven (1986) mentioned that “As long as the idea is perceived as new by the people involved, it is an ‘innovation’ even though it may appear to others to be an ‘imitation’ of something that exists elsewhere” (Van de Ven, 1986).

According to Damanpour (1991), innovation defines as “Adaption of an internally generated or purchased device, system, policy, program, process, product or service that is new to the adopting organization” (Caputo et al., 2016; Damanpour, 1991). Another definition for innovation has been proposed by Zahra & Covin (1994) that “Innovation is widely considered as the lifeblood of corporate survival and growth” (Zahra & Covin, 1994).

Next definition combine change with newness which leads to the definition that proposed by Damanpour (1996) that “Innovation is conceived as a means of changing an organization, either as a response to changes in the external environment or as a pre-emptive action to influence the environment” (Damanpour, 1996). Another definition has been defined for innovation by Bessant et al. (2005) which concentrates on the key role of innovation in renewal and development. The definition is “Innovation represents the core renewal process in any organization. Unless it changes what it offers the world and the way in which it creates and delivers those offerings. It risks its survival and growth prospects” (Bessant et al., 2005). The last definition concentrates on the various disciplinary viewpoints. For instance, the term innovation in the field of knowledge management is considering the importance of knowledge in innovation; in this regard, Plessis (2007) defined “Innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market-driven products and services” (Plessis, 2007).

A broad and continuing acknowledgment have existed for the significance of innovation in the UK. The department of trade states that there is a connection between innovation, works, revenue and living standards in 2003. In other words, lack of innovation in the UK leads to works and revenue suffering as well as degeneration of living standards in compare to other

countries. In recent years, the departments of innovation universities and skills have been remarked upon the widespread effects of innovation in the face of globalization and ecological challenges. The emphasis is on the significance role of all kinds of innovation in order to building and maintaining competencies with the aim of reply to the ecological as well as demographic limitations (Baregheh et al., 2009).

Survey of innovation reveals that innovation categories in two groups; sustaining innovation and disruptive innovation which are in the opposite direction (Paetz, 2014). According to Sandberg (2002) and Raulerson et al., (2009), sustaining innovations equate with incremental innovation while disruptive innovations equate with a radical innovation in many places (Sandberg, 2002; Raulerson et al., 2009). Sustaining innovations concentrate on incremental improvement on current technology in a way that firms target the best customers for selling larger margin products. Incumbents' resistance to disruptive innovation is because of the various reasons such as organizational inertia, path dependencies, and highly profitable customers. Therefore, three alternatives have been defined by Christensen and Raynor (2003) for incumbent companies to proactively follow disruptive innovation. The first one is making a shift in the procedures and values of the existing company while establishing an independent company is the second option and the third alternative is gaining a distinctive company (Cowden & Alhorr, 2013; Christensen & Raynor, 2003).

On the other hand, disruptive innovations concentrate on the customers who were not satisfied with the previous products or services in a way that adapts to current technologies perfectly simple. Disruptive innovation from a market point of view considers as a low-end encroachment. It means that companies target the vast majority of customers by providing a low-cost version of the current solutions. Due to this, entrants are attracted to disruptive innovation. The case of General Electric's portable ultrasound machine with low cost can be named as a disruptive innovation (Cowden & Alhorr, 2013).

3.1.1 Concept of Sustaining Innovation

The term sustaining innovation has been defined by Christensen (1997) as an innovation that "improve the performance of established products, along with the dimensions of performance that mainstream customers have always valued'' (Christensen, 1997).

Therefore, having knowledge about the lower level of product class is required because of the nature of this type of innovation which create improvements based on the similar performance dimension. On the other hand, sustaining innovation enhances the main performance dimension with a higher level of price. Consequently, the consumers of the sustaining innovation are the ones who have enough monetary resources (Reinhardt & Gurtner, 2015).

Sustaining innovation not only addresses customers' requirements in the current market but also produces the products that have the ability to satisfy predicted requirements for the future. Well-established market leaders have high ability to tackle and utilize sustaining innovation to provoke short-term development for their organizations (West, 2012). Additionally, the concentration of sustaining innovation is not related to enormous shifts. In this type of innovation, companies concentrate on the costs and attributes of the current products, services, production techniques and procedure with the aim of performance development (Caputo et al., 2016).

Sustaining innovations enhance performance with the main concern to mention value for customers all the time. This type of innovation is based on the existing customers' preferences and requirements. Increase in the pictures' quality for television from black and white to color, HD and 3D can be named as the example of sustaining innovation, while in-ear headphones, Wi-Fi memory cards, blue-ray players, cooling pads, USB record players, iPod sound systems and 3D cameras are also among the relevant example of the sustaining innovation (Reinhardt & Gurtner, 2015).

The main aim of sustaining innovation is to provide suitable opportunities for the current customers as well as make the possibility of higher-end uses. In other words, the quality and reliability of the older products will improve with extra attributes. Apart from the type of innovation which can be incremental, small innovations or breakthroughs, the main concern is to enable current customers with more facilities as well as providing competitive advantages. For instance, proposing extra features such as using an additive material such as Fluoride, whiteners to toothpaste, change the size, flavor, color and packaging of the toothpaste can be named as an example of the sustaining innovation. Another example for sustaining innovation is the new car models and advanced engine technologies including hybrids, electrics and other option for fuel vehicles. Moreover, a major upgrade to software

including an update from Windows 7 to windows 10 is considering as the example of sustaining innovation (Paetz, 2014).

3.1.2 Concept of Disruptive Innovation

Disruptive innovation has become as one of the tough subjects for both academia and practices (Reinhardt & Gurtner, 2015). Therefore, ignorance of disruptive innovation leads to the consequences like insolvency and scaling market share down. Therefore, market incumbents should treat projecting disruptive innovation with utmost importance (Nagy et al., 2016). The concept of disruptive innovation shifts the procedure of creating products or services. This new process changes the market performance from customer expectations and competition to new performance attributes (Keller & Hüsig, 2009). Furthermore, existing literature review on disruptive innovation focuses on valuable perspectives about different aspects of disruptive innovation and its managerial implications. But the past survey on this issue, considering industrial impacts, innovative approach during the uncertain time, and managerial manners through disruptive innovation (Cowden & Alhorr, 2013).

Many different critiques and improvement of Christensen's concept have been reviewed in order to illuminate the concept of disruptive innovation. A demand-based view and low-end disruption introduced by Adner (2002) and Christensen & Raynor (2003), respectively. They introduced the same view which focuses on the absolute lower unit price for disruptive innovation occurrence (Adner, 2002; Christensen & Raynor, 2003).

Christensen and Raynor (2003) introduced a new definition for disruptive innovation by introducing "new-market disruption" and "low-end disruption". New-market disruption is an innovation which established with the creation of a totally new market. This type of innovation proposes a group of new products or technology that current customers don't value at the beginning (Christensen & Raynor, 2003; Reinhardt & Gurtner, 2011). Moreover, New-market disruptive innovations consider the market segments that have not been provided by incumbents, while achieves distinct groups of favorable results with unclear application and methods initially (Paetz, 2014). Sony's first mobile radio and the first personal computer can be named as an example of new-market disruptive innovation because the people don't value the products and technology initially. The invention of

Sony's first mobile radio has satisfied teenagers with the new technology or product because they can listen to music out of home (Christensen & Raynor, 2003; Reinhardt & Gurtner, 2011). Twitter can be named as another example for the new-market disruptive innovation which leads to dramatic shift and rises in customer services, tracking and broadcasting (Paetz, 2014). Therefore, there is a competition between non-consumption at the beginning in new market innovation (Christensen & Raynor, 2003; Reinhardt & Gurtner, 2011).

Low-end disruption is based on a novel business model that answers the smallest amount of demanding customers in specific market segmentation (Christensen & Raynor, 2003; Reinhardt & Gurtner, 2011). This type of innovation consider the customers with lower expectations in terms of price due to production techniques, quality and the group of characteristics that proposed by incumbents. This kind of disruptive innovation attracts the market segments which are unfavorable to the existing market leaders (Paetz, 2014). Teel mini-mills, discount retailing and Korean car manufacturers in North America are among the example of low-end disruption. These two types of disruptive innovation have a separate performance but they have overlap with each other. For instance, although notebooks create a new market for the ones who needs smaller device and wants to pay less money than a laptop, simultaneously notebooks grasp the attention of the least demanding customers in a laptop market (Christensen & Raynor, 2003; Reinhardt & Gurtner, 2011).

High-end disruption recognized by Govindarajan & Kopalle (2006) which firstly seems to be in contrast with the previous view because of the high price of the new solutions in compared to current solutions. Price is the main performance attributes for products and service in this view and incumbent dismissed this view due to its high price. After that Govindarajan & Kopalle (2006) follow demand-based view and describe the switch in the customer expectation by the use of disruptive innovation result in enough performance attributes, while proposing an extra performance attributes (Adner, 2002; Christensen & Raynor, 2003; Govindarajan & Kopalle, 2006; Keller & Hüsig, 2009).

Govindarajan and Kopalle (2006) define disruptive innovation as specific kind of innovation that concentrates more on market perspective instead of a technology viewpoint (Govindarajan & Kopalle, 2006). According to Christensen and Bower (1996) research, incumbents neglect disruptive innovation because of the lack of strong tendency by mainstream customers as well as its uncertainty nature. But a continued improvement in the

performance of disruptive innovation results in shifting to disruptive technology during a time. Consequently, concerning focal attributes for the requirement, getting more benefits from the new technology for established market and the low cost of the new technology may cause shifts to disruptive innovation (Christensen & Raynor, 2003; Reinhardt & Gurtner, 2011).

Next definition for disruptive innovation concentrates on market characteristics. This definition recommended by Danneels (2004), Markides (2006) and Tellis (2006) which changes the attention away from market strategy onto paralleling innovation's features with customer expectation (Danneels, 2004; Markides, 2006; Tellis, 2006; Nagy et al., 2016). In theory, functionality, technical standards, and form of ownership of the technology are proposed as the constructs for disruptive innovation. According to this the proposed definition of disruptive innovation which advocates by Danneels (2004), Markides (2006) and Tellis (2006) has been changed. Therefore, refinement of the previous definition describes disruptive innovation as "an innovation that shifts the performance metrics and customer expectations of the market by providing a novel form of ownership, radically a novel functionality, and discontinuous technical standards". This technique mainly relies on the manager's cognition in a broader context of both organization's innovation and potentially disruptive innovation. In order to recognize disruptive innovation before disruption in organizations, three different steps have defined for managers in this method. The first step is to recognize innovation and its characteristics in terms of functionality, technical standards, and form of the ownership of the technology. Identifying the place of innovation has been utilized in the organization's value chain is the second step. The final step is to make a distinction between the potentially disruptive innovation and the current technologies that are used in the organization for specific value chain segment (Nagy et al., 2016).

Different assumptions have been conducted about the disruptive nature of the innovation in establishment of the organization. Fenech & Tellis (2016) believe that disruptive innovation can happen automatically by following some characteristics of disruptive innovation (Fenech & Tellis, 2016). In this definition, adoption introduces as a vital feature for disruptive innovation. Therefore, the term disruptive innovation mainly relies on adaptation and the way that adaptation is disruptive in specific actors such as market, organization or innovation. Moreover, there is another assumption that named "potential disruptive

innovation". It describes that there is a probability that innovation is disruptive not only by design but also by some characteristics of disruptive innovation. For instance, Google Docs is an example of disruptive innovation by design to the Microsoft Office. Tata Nano car is another example of disruptive innovation by design the auto industry. Though these cases never turned to disruptive innovation from the initial stage, they can meet the characteristics of the disruptive innovation during a time (Baiyere, 2015).

Innovation with both "good enough" functionality and low cost define as another definition for disruptive innovation. Describing a clear definition for disruptive innovation is difficult due to the existence of two different types of disruptive innovation. New-market innovations and low-end innovation can be named as different sort of disruptive innovations which have various impacts on markets. New-market innovation relies heavily on creating new demand for novel technology while low-end innovation depends on the current technologies with less sustainability cost (Nagy et al., 2016).

All the above definitions for disruptive innovation are related to the characteristics that are external to an innovation. The characteristics of innovation must be intrinsic for itself. In other words, market factors, cost, quality, customer expectation and performance metrics as an innovation characteristics are features that can be changed during a time or by different factors such as user, owner, and market. According to the Christensen's definition disruptive innovation addresses innate characteristics for innovation that can result in the marketplace disruption (Nagy et al., 2016).

Five different features for disruptive innovation have been recognized by Keller & Hüsig (2009) which state as follows (Keller & Hüsig, 2009):

1. Products or services can utilize innovation which has a set of performance attributes including price.
2. Disruptive innovation targets niche market because of missing the key market expectations in established features.
3. Disruptive innovation face with the ignorance of the niche market by incumbents due to the lack of compatibility with their procedures or values.
4. The products or services which propose by entrants improve the innovation more and try to satisfy the key market expectations in established performance attributes.

5. Incumbents face with failure because of the lack of ability to create novel performance attributes and the essential competencies dismiss in the innovation.

In order to have outstanding results and be successful in disruptive innovation, other factors are needed. Collecting right information about potential and current customers can be named as one of the important factors for creating disruptive innovation. Furthermore, proper recognition of competitive analysis, drivers of market parameters, and assessment of disruptive channels can be defined as other items for the success of disruptive innovation (Reinhardt & Gurtner, 2011). Moreover, the nature of the disruptive innovations is recognizable because of the identifiable attributes that they have. These characteristics are the following (Paetz, 2014):

- Inferior quality among the existing options.
- Concentrate on requirements that are underserved in the first market segments.
- Focus on a small marker niche at beginning.
- Lack of attractiveness to incumbents for their customers.
- Created for moderate to low increase segments.
- Designed by outsiders like startups.
- Enable a number of benefits for the new consumers like user-friendly, simplicity, convenient, flexibility (especially the ones that have not considered by others)
- Concentrate on various distribution channels both direct and indirect one.
- Competition among non-consumption.
- Have a sustainable cost of production benefits which provided by new business procedures or innovative technology.

Scarcity, default corporate management behavior and human nature are among the indicators that introduced by Paetz (2014) to predict disruptive market quickly. The occurrence of scarcity depends on different factors such as lack of alternatives, monopoly or oligopoly control of supply and unclear production cost. In other words, noticeable low price switches demand curve because of enabling low-end users and creating different service or product options eliminate monopoly or oligopoly control of supply. Therefore, disruptive innovation is provided by the creation of abundance from scarcity (Paetz, 2014).

Default corporate behaviors can be named as the second enabler for disruption reason in the market. In other words, increasing profits and stockholder values are among the main role of the corporation. This factor as the reason for disruptive innovation is not really clear and needs some investigation. Concentration on operational efficiency, short-term results and calculating the rate of return for innovative technology or products are among the corporate behavior (Paetz, 2014).

A Long time ago, collecting and creating a database for information were very complicated and expensive, while today "cloud" provides facilities to search and download much different information without any costs. The vast number of data is generated hourly by the use of various sources like Twitter, Facebook, internet searches, blogs, RFID information and real-time sensor data which collected from smart devices. The set of the information that provided from mentioned resources called "Big Data". Consequently, big data creates abundance from scarcity. Therefore, utilizing big data in different fields results in disruptive innovation (Paetz, 2014).

Disruptive innovation leads to drastic changes which shift the methods of competition and current markets or industries. For instance, disruptive innovation will open up opportunities for new market creation and transform the structure of the market which causes increasing uncertainty. The recognition of disruptive innovation might be time-consuming and it is not clear especially after the advent of business (Caputo et al., 2016).

Discontinuous, highly disruptive technology results in enormous shifts at all levels. Therefore, senior managers have to convince others to shift in a new direction. (Jr. & Goh, 2009). In order to understand the nature of the disruptive innovation, the example of disruptive innovation in a wide range of industries has been shown in *Table 2* (Dedehayir et al., 2014).

Table 2: Application of disruptive Innovation in a different industry (Dedehayir et al., 2014)

Industry	Incumbent Technology	Disruptive Technology	References
Automotive	Compact car concept	Cheap car concept	(Johnson et al., 2008)
Banking	Traditional lending practice	Credit scoring technology	(Christensen et al., 2002a)
Cash management	Brocken mediated deal	Online brokering	(Christensen et al. , 2000)
Chemical	Trial and error development	Theory based development	(Christensen, 2001)
Computer	Personal computer	Laptop microcomputer	(Christensen & Bower, 1996)
Computer memory	Large hard disk drive	Smaller hard disk drive	(Christensen & Rosenbloom, 1995)
Computer printer	Laser printer	Ink-jet printer	(Christensen et al., 2006b)
Computer router	Voice call the only router	Routers cable of VoIP	(Christensen & Euchner, 2011)
Computer software	Large software for enterprises	Simple software for SMEs	(Johnson et al., 2008)
Construction	Large inventory of spare parts	Overnight air freight	(Christensen , 2001)
Dental care	Normal toothpaste	Fluorescent-reinforced toothpaste	(Christensen e al., 2005)
Earth excavation	Cable shovel excavator	Hydraulic excavator	(Bower & Christensen, 1995)
Education	Classroom-based education	Online based education	(Christensen et al., 2006a)
Energy production	Centralized production	Decentralized production	(Hart & Christensen, 2002)
Health care	Doctor-provided treatment	Nurse provided treatment	(Christensen et al., 2000)
Insurance	Insuring cooperate-employed	Insuring independently employed	(Christensen et al., 2006a; Christensen et al., 2006b)
Internet	Residence-specific connection	Internet connectivity kiosk	(Hart & Christensen, 2002)
Microprocessor	Traditional design, large scale production	Modular design, mini fab	(Christensen, 2001)
Microwave	Fully functional oven	Energy efficiency oven	(Hart & Christensen, 2002)
Motorcycle	Harley Davidson-type	Affordable and humble	(Hart & Christensen, 2002)
Music player	Stand-alone player	Integrated with content	(Johnson et al., 2008)
Package delivery	Priced-base	Speed and reliability based	(Johnson et al., 2008)
Passenger airline	Full service airline	Low fare airline	(Christensen , 2006)
Pharmaceuticals	Trial and error development	Genetic technology development	(Christensen et al., 2004)
Photocopying	Large photocopier	Small photocopier	(Bower & Christensen, 1995)
Photography	Photographic film processing	Fully automated film processing	(Christensen et al., 2008b)
Restaurant	Traditional restaurant	Fast food restaurant	(Christensen & Euchner, 2011)
Retailing	Department store	Discount department store	(Christensen & Tedlow, 2000)
Semiconductor	Production in fab	Roll to roll production	(Hart & Christensen, 2002)
Steel production	Integrated steel mill	Mini mill	(Christensen et al., 2008a)
Telephone	Circuit-switching networks	Packet switching networks	(Christensen et al., 2002b)
Television	Black and white television	Color television	(Christensen et al., 2004)
Textile	Cotton spinning	Synthetic fiber production	(Christensen et al., 1996)
Travel agency	Full-service agency	Online travel agency	(Christensen et al., 2002a; Christensen et al., 2002b)

3.2 Challenges in Disruptive Innovation for Sustainability

Innovation has been introduced as the component of corporate strategy as well as a possible source of sustainable development for companies which achieved by the use of making shifts in products, processes, business model, and organizational structure. In recent years, innovation can be named as the main way to improve sustainability, and enhance competitive advantages in marketplace (Kennedy et al., 2016).

The vast numbers of methods exist for the improvement of social and environmental performance of the organizations. These techniques can be limited to small changes in products/services or production process or new disruptive shifts in product process. Frequently, investigation on product functionalities as well as customers' requirements results in the disruptive or radical new products or services which improve customer satisfaction. Interface Incorporated can be named as an example of disruptive innovation for sustainability. The innovation in this company is that Interface leasing the floor carpeting rather than selling. In this way, carpets take back after use and recycle and help the environment by reducing the number of wastes in landfills. Moreover, the level of customer satisfaction has been improved and the company enables to keep the customers in high level and the use of recycled material in an efficient way (Epstein & Roy, 2001)

Flash converting technology introduces in the copper production industry in 1995 as a complex production system technology that promotes the purity of the copper. Flash converting technology represent the disruptive innovation, especially in greenfield industry, because this technology not only satisfies the customers' requirements but also providing extra values such as reducing emissions and enhancing complete online availability. Furthermore, Nanotechnology can be named as the disruptive innovation due to its disruptive shifts in a vast number of industries such as material, automotive, aerospace, healthcare and electronic production (Dedehayir et al., 2014).

The importance of responsibility for the large contexts such as external forces, regulations, stakeholder interests as well as industry knowledge in "Innovation for sustainability" is more than "innovation". Innovation for sustainability has been investigated in three different levels. First one is an incremental innovation which includes innovation in the level of products, services as well as processes. Radical or disruptive innovation is located in the second place which consists of a broad range of activities and closer degree of interaction

with suppliers, regulators, and civil organizations as well as other stakeholders. The last one is game-changing innovation that encompasses strong changes in practices, structure as well as goals of the business (Szekely & Strebel, 2013). In this research, the main concern is about the challenges and enablers of disruptive innovation for sustainability.

Closing the loop can be named as one of the enablers of disruptive innovation for sustainability. Changing the way of thinking from linear to closed loop, leads to making the shift from eco-efficiency to eco-effectiveness. Eco-efficiency describes the actions that require for toxic emission reduction as well as maximization of productivity and lifespan while eco-effectiveness viewpoints are related to the industry activities have the ability to influence and direct for supporting the recreation of environmental systems by establishment of an exchange thoughts between biological and technical material flows. Moreover, enhancement in eco-efficiency involves reactionary, incremental as well as linear activities while the implementation of eco-effectiveness encompasses proactive exchange of poisonous materials, making the new interaction between the product and the consumer as well as the act of creating cradle-to-cradle loops (Szekely & Strebel, 2013).

“Mirra” chair is the example of disruptive innovation for sustainability which is created by the American furniture company called Herman Miller cooperated with the McDonough Braungart, Design Chemistry Company. These two companies try to apply innovative process for a novel ergonomic chair by the development of tailored “Design for the environment”. They make changes to chemicals and elements in order to enhance the performance of products in terms of material poison, ease of detachment as well as recyclability (Szekely & Strebel, 2013).

Transforming supply chain is another perspective for enabling disruptive innovation for sustainability. Disruptive innovation for sustainability among firm’s supply chain is a system’s perspective of the effects of a firm’s product or services, processes as well as operations on problems throughout product design, sourcing, production process, materials’ selection, delivery, and disposal as well as the end of life. Strong relationship between multinationals and suppliers from developing countries are continuously changed. It is very important to consider the social effects of the business in its value chain with addressing not only a basic level of requirements such as decreasing poverty as well as enhancing human health but also a high level of requirements including education, gender equity and quality

of life. In recent years, sustainable agriculture, as well as markets for producing sustainable goods have become very important. Unilever's complete changes to produce sustainable tea with the help of Lipton brand cooperated with international NGO Rainforest Alliance (RFA) can be named as an instance of disruptive innovation for sustainable agriculture. RFA has been addressed three different parts. The first one is about employee welfare such as setting standards for working environments and occupational health. The second one is farm management which encompasses requirements for soil management as well as integrated crop management. The last one is about ecological protection which includes setting targets for water preservation as well as wildlife protection. Different challenges such as lack of knowledge and skills, difficulties in legislations for auditing and finding precise information has been faced with this method and can be tackled with making growth in additional partnerships with local organizations or creating multiple partnerships with various teams in each country. It means that these challenges will overcome by the cooperation of with RFA, local NGO as well as industry teams (Szekely & Strebel, 2013).

Leapfrogging the unsustainable can be defined as the third enabling factor for disruptive innovation for sustainability. "Leapfrogging" can be described as the growth strategy that achieves with the help of skipping straight to advanced clean technologies makes the possibility for nations to keep away from the polluting phase of the economic development. "Leapfrogging" can be considered from various perspectives such as enormous economy-broad growth pathway, the method for "latecomer" countries in order to improve with industrialized nations or technological transformation. Companies which located in developing countries have the ability to track various leapfrogging pathways including path tracking, phase jumping, path creation or disruptive innovation. On the other hands, late comers companies can achieve more benefits from learning economies. Furthermore, they make the possibility of businesses in developing nations to skip straight to the most recent ecological technologies without changing among different polluting steps of the industrialization. Jump from coal to renewable energy in China and India can be named as the example of disruptive innovation for sustainability which achieves by stage-skipping leapfrogging. Support activities from the favorable institution, government policies as well as a foreign direct investment are required for leapfrogging to be successful in this method (Szekely & Strebel, 2013).

Sustainability partnership is a voluntary collaboration among different actors from more than one sector with the aim of sustainable goal achievement. Multiple stakeholder alliance including the Marine Stewardship Council or Roundtable on Sustainable Palm oil might target for disruptive innovation but the moving has been stopped by the lowest common denominator which leads to being delicate and inefficient incremental innovation. Disruptive innovation needs partnerships in much deeper level with the vast variety of stakeholder groups. “Suzlon” which creates diverse interactions in India and Denmark is the example in this regard (Szekely & Strebel, 2013).

One challenge in applying innovation for sustainability is the balance between three dimensions of sustainability. In other words, the transformation that applied in order to improve the performance of one dimension might reduce the performance of the other dimensions which called as “directional risk”. Adopting an integrated approach requires various components including recognizing and filling knowledge gaps, creating capabilities, considering sustainability as an important part of everyday activities as well as constructing bridges between companies to keep directional risk away (Szekely & Strebel, 2013).

Employees’ resistant in the early stages of thinking about making changes and innovation for sustainability can be named as other challenges in organizations. Especially in disruptive innovation which requires both hard and soft skills as well as multidisciplinary systems approaches, the occurrence of disruptive innovation for sustainability without top-down directive approaches is impossible. For instance, the CEO of the Herman Miller’s company had been spending many decades and provide guidelines and impetus to enhance sustainability performance which leads to “Mirra” chairs. Therefore, previous knowledge and experience lead to lower the level of resistance from the employees (Szekely & Strebel, 2013).

In addition to all the enablers and barriers that have been mentioned above, there are some other factors to enable or disable the occurrence of innovation for sustainability. The enabling factors in innovation for sustainability are divided into two various groups. The first one is internal factors, including competition, knowledge, culture and capabilities of the organization. The second one is external drivers which encompass both physical and biological shifts to natural environments, the evolution in terms of scientific understanding of these shifts, needs for reduction of natural resources, governmental policies, and

regulations, social pressure, as well as customer demands. On the other hand, the barriers to innovation for sustainability are considered in three various levels. In the firms' level, barriers such as lack of knowledge and skills, having fear of making trade-offs through quality and sustainability performance, well-established pathway dependencies, as well as delicate customer demands are among the barriers of disruptive innovation for sustainability. Delicate voluntary agreements as well as creation of perverse motivations by public policies can be named as the barriers in local, national and international levels while at all levels, the barriers of disruptive innovation for sustainability includes lock-in to wasteful, high reliance on fossil fuels, and the linear system from individual behaviors to companies' structures to socio-technical governments (Szekely & Strebel, 2013).

4 IOT AS EXPRESSION OF DISRUPTIVE INNOVATION

The introduction of Internet of Things (IOT) will change the living manner. In near future, many different home instruments can get more benefit from the knowledge of artificial intelligence. These devices can have online connections and remote communication with each other. Currently, home devices strongly rely on the human action while in near future the home devices will work based on a novel communication system. For instance, refrigerators will equip with a camera which can connect with other devices like cell phones and do shopping according to the available products in the market and the finished one inside the refrigerator (Constantinescu, 2015).

The concept of IOT has originated from the Auto-ID Labs, which is the global group of academic research laboratories in the area of networked RFID, as well as emerging sensor technologies. The main target of this institution from the beginning was the architecture of IOT with Electronic Product Code (EPC) universal. Development of EPC with the aim of supporting broad usage of RFID in universal high-tech trading networks, as well as the creation of industry-driven universal standards for EPC global network, are the main concentration of this institute. These standards can be applied in order to enhance the visibility of objects such as object tracking, being aware of its locations, status, and so forth. These standards can be named as one of the main components of the complete deployment of IOT perspective which could be an appropriate reason for the importance of IOT concept (Atzori et al., 2010).

The IOT is not limited to RFID, sensors or machine to machine communication which can connect with other gadgets, it enables information exchange with people, and devices in a way that creates application, and service that are novel in scales and by being connected to abilities in large data analysis. IOT makes fundamental shift in governmental challenges, social, and ethical risks, as well as the method of doing things (Dutton, 2014).

Cisco, which is the leading IOT solution provider, estimates that the number of objects which is connected to the internet varies from about 200 million to 10 billion during 13 years, from 2000 to 2013, and will reach to 50 billion things include people by 2020. The application of IOT in a different industry will grow over time. According to the International Data Corporation (IDC) forecast, the global market for IOT will shift from $655 billion in 2014 to $1.7 trillion in 2020 (Byun et al., 2016)

Consequently, the effects which this paradigm will have in everyday life, make it more important which can be seen in various working and domestic fields. E-health, education, logistics, process management, automation, manufacturing, and intelligent transportation are among the subjects that can reap the benefit of IOT (Atzori et al., 2010).

4.1 Background of IOT

The growth of IOT dates back to a few times ago. The first sign of IOT has been seen in the landmark paper by the exploration of RFID by Harry Stockman in 1948 (Stockman, 1948). Simultaneously, many different firms such as Raytheon's Raytag in 1973 and Richard Klensch of RCA in 1975 managed to improve RFID technology (Landt, 2005; Yang et al., 2009). After that, an open architecture computer system which called TRON with the ability to make the identifier for all items has been introduced by Sakamura in Tokyo in 1987 (Sakamura, 1987).

Four years later, the first Electronic Toll Collection (ETC) system has been found in 1991 in USA (Gillen et al., 1999). In the same year, Weiser (1991) has been promised in his article that the application of computers will spread out around the world (Weiser, 1991). In 1995, the concept of IOT has been stated by Bill Gates in his book under the title of "The road ahead" (Gates, 1995).

The key role of sensor network on mobile computing and networking, has been mentioned in the different international conference in 1999 (Tao et al., 2016). After that, sensor network became a hot topic around the world, whereas Kevin Ashton has been found Auto-ID center at Massachusetts Institute of Technology (MIT), who introduced the term IOT based on supply chain management for the first time in 1999 (Ashton, 2009).

Gradually, the concept of IOT has been agreed by academics and practitioners while in 2001 the concept of "Smart Dust" has been proposed by (Warneke et al., 2001). In 2002, Oak Ridge National Laboratory in the US had a promotion that the term "Sensor is the network" would replace with "Computer is the network" in the future. In 2003, EPC universal was established in the United States in order to create IOT to enables automatic identification of different things from distinctive source.

In January 2005, Wal-Mart, which is an American multinational corporation, declared that about 100 enormous retail stores would begin to utilize RFID tags at the same time. Moreover, simultaneously the companies such as IBM, Tesco, and Microsoft begin to use RFID tags in their companies (Tao et al., 2016). In November 2005, International Telecommunication Union (ITU) published the report which was related to IOT and makes this knowledge more official for the industries and the users. ITU defines IOT as a "New dimension has been added to the world of information and communication technologies (ICTs): from anytime, anyplace connectivity for anyone, we will now have connectivity for anything. Connections will multiply and create an entirely new dynamic network of networks – an IOT" (Srivastava et al., 2005; ITU, 2005; Borgia, 2014).

In 2008, the universal conference under the title of IOT was held in Zurich for the first time. In 2009, the CEO of the IBM concentrated on the "Smart planet" by the use of IOT technology (Haller et al., 2008).

In addition to this, in 2012, ITU has been presented new definition for IOT as a "global infrastructure for the information security, enabling advanced services by interconnecting (physical and virtual) things based on existing end evolving interoperable information and communication technologies" (Wortmann & Fluchter, 2015; Atzori et al., 2010). As the definition of IOT in the previous decades has been changed by the development of technologies, but they are still the same in the main aim, which is making the computer sense information without the intervention of human being (Srivastava et al., 2005; Borgia, 2014).

Figure 5 shows the milestones in the brief history of IOT from 1948 until 2012 with the aim of describing the contribution of IOT during 65 years (Tao et al., 2016).

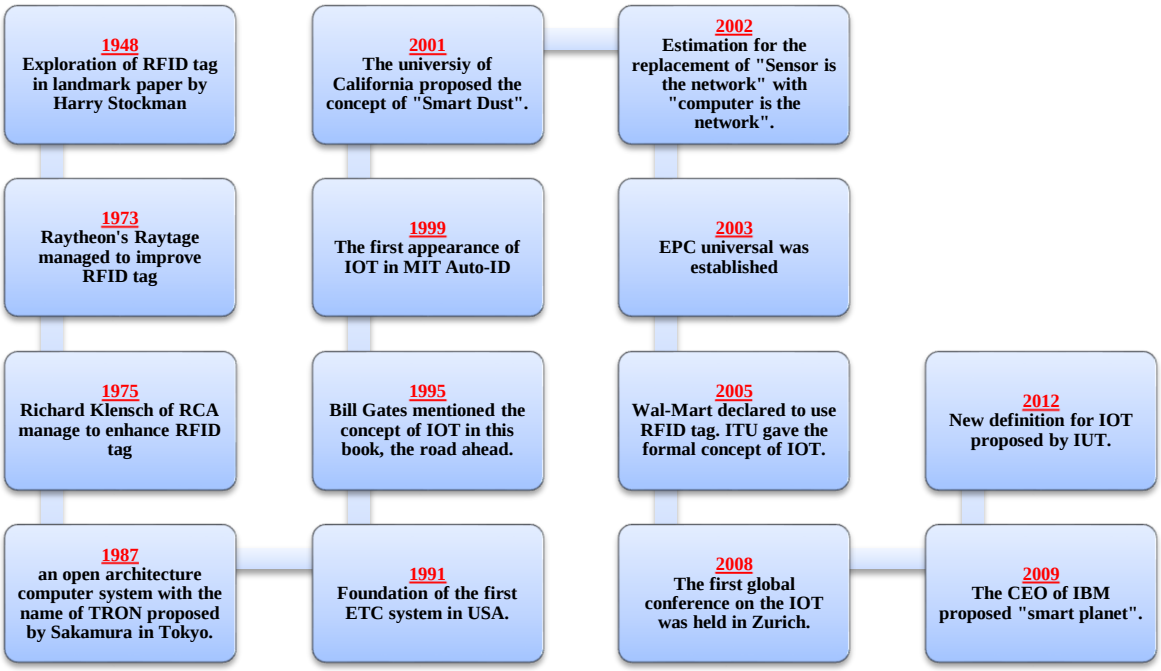

Figure 5: Brief history of IOT (Tao et al., 2016)

The radical transformation of the current internet to the network interconnected objects results in collecting information from the physical environment including sensing, interact with the entire worlds such as control, actuation, and command, utilizing the internet in order to provide services such as communication, analytics, information transfer, and applications. Moreover, the wireless technology devices such as RFID, tags, Bluetooth, Wi-Fi, sensors, and actuators make this technology more powerful (Buckley, 2006).

The revolution of internet results in human's interconnection at an exceptional speed and level. Interconnecting objects with each other in order to provide smart environment will be defined as the next revolution. The current situation is the existence of 9 billion interconnected devices and it is predicted that to reach the level of 24 billion devices by 2020 (Gubbi et al., 2013).

According to Gartner Incorporated estimation, in 2015 the number of connected things, with 30% increase in compared with the year 2014, reached 4.9 billion and this number will reach 25 billion by 2020. Gartner Incorporated will expect that a quarter billion of these devices are vehicles which lead to novel transportation service and self-drive capabilities in 2020. In

the following five years, societies will be witness to the drastic increase in the number of automated driving capabilities, and connected cars will be a main element of IOT (Meulen & Rivera, 2015; Yu et al., 2016).

A mixture of physical and digital component results in innovation in the IOT in order to produce new products and services, as well as the creation of the novel business model. According to *Figure 6*, the IOT solutions combine physical things with IT in the form of software and hardware which results in the value creation. As shown in *Figure 6*, bulb as the things just provides light for a specific place. But with the concept of IOT recognition of human's presence in place and provision of low-cost security system will be possible. The bin can be named as another example with the application of storage capacity as the things. However, with the utilization of IOT, the application of bin can shift to an instrument which enables measure and monitor storage weight and offer automatic replenishment service. The main application of tractor without IOT concept limited to pull the farm instrument, while IOT will provide service improvement, efficient use of equipment and early maintenance activities. Moreover, watch with the technology of IOT can enhance its application to make E-call, apart from showing date and time. Therefore, the technology of IOT enhances the performance of objects which facilitate and sustain activities for personal usage, businesses, and industries (Wortmann & Fluchter, 2015; Fleisch et al., 2014).

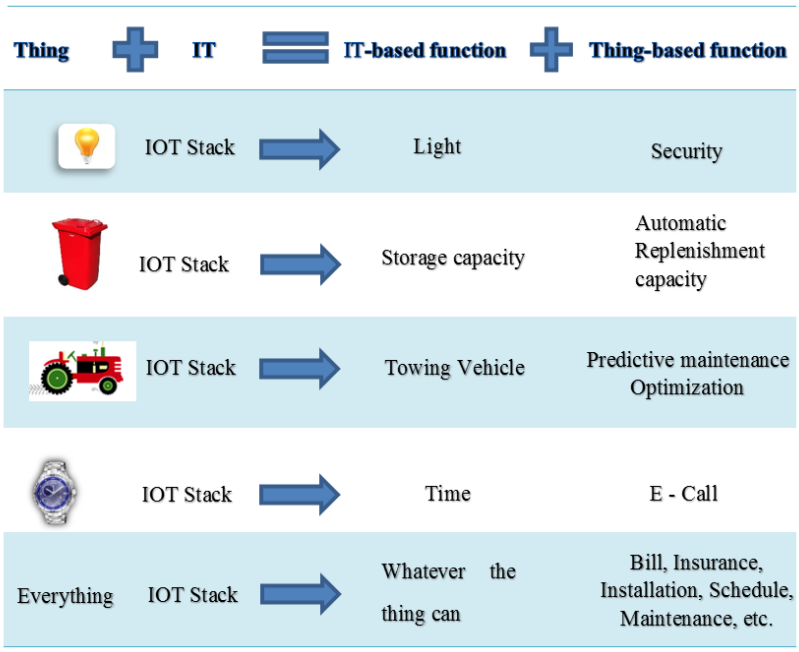

Figure 6: IOT-Product-Services logic (Fleisch et al., 2014)

Therefore, the extreme growth of the internet has changed the small research network with a few nodes to the global pervasive network with more than a billion users during the past 30 years. Cost cuts, as well as additional miniaturization of devices, provide expansion of the internet into a new dimension. For instance, physical devices with embedded electronic devices enable local connectivity, as well as intelligence cyberspace which found by the internet. The gap between the information world and physical world will fill with embedding electronic device and computational element in physical things (Yu et al., 2016).

4.2 The Concept of IOT

The term “Internet of Things” encompasses with the words “Internet” and “Things” which lead to the manifold definition for IOT. The term “Internet” is “The world-wide network of interconnected computer networks, based on a standard communication protocol, the Internet suite Transmission Control Protocol (TCP) /Internet Protocol (IP)”, while “Things” defines as “an object not precisely identifiable”. Consequently, a combination of these two words creates the disruptive level of innovation in ICT knowledge and leads to a semantic definition for IOT as “a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols” (Santucci & Lange, 2008).

As shown in *Figure 7*, Atzori et al. (2010) have been defined IOT by the combination of three paradigms; things-oriented (sensors), internet-oriented (middleware) and semantic-oriented (knowledge) (Atzori et al., 2010). The first one is according to things related aspects which the concentration is based on connections of things in IOT. The second one is the internet related aspects definitions which focus on IP and network technology. The last paradigm is limited to the semantic challenges in the IOT such as storage, search, and management of huge number of information (Wortmann & Fluchter, 2015; Atzori et al., 2010).

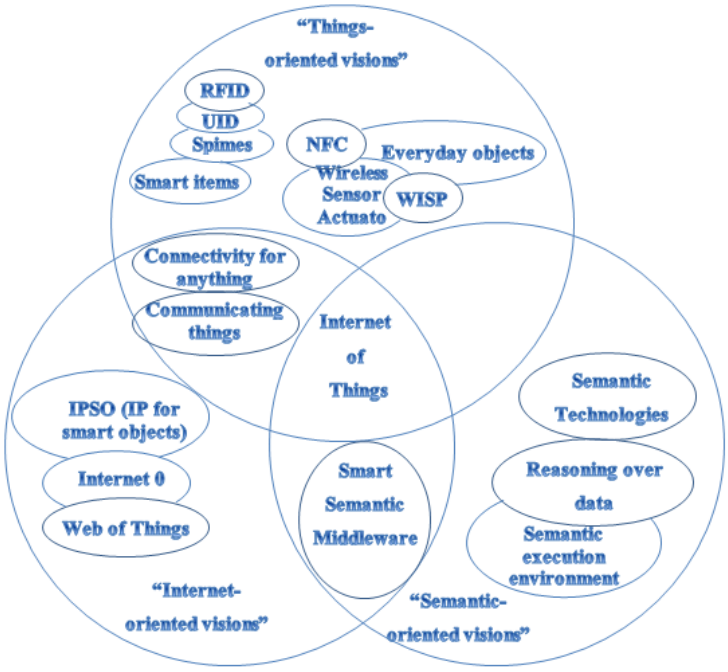

Figure 7: Convergence of IOT paradigms (Atzori et al., 2010)

According to different perspectives, other definitions have been stated for this concept. With the consideration of functionality and identity as the central focus, IOT describes as "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts". Concentration on seamless integration provides the definition of IOT as "Interconnected objects having an active role in what might be called the Future Internet" (Santucci & Lange, 2008).

On the other hand, according to RFID Group viewpoint, IOT can be defined as "The worldwide network of interconnected objects addressable based on standard communication protocols" (Gubbi et al., 2013). From the Clusters of European research projects points of view, "Things" have "an active involvement in business, information and social procedures where they are able not only to interact and communicate among themselves and their surroundings by the use of transferring information and data which are sensitive to the environment, but also responding independently to the real world happenings and effecting it by creating an activity that operate actions and create service with or without the aid of human intervention" (Sundmaeker et al., 2010).

The term IOT defines as a universal infrastructure based on the network which uses many different things including physical devices or virtual things with features, Auto-ID, and self-configuration receptivity within the standard communication. In other words, everything such as consumers, things, as well as spatial data is connected with each other via the internet which leads to the creation, collection, and utilization of the information. IOT also describes as a new paradigm which distributed in modern wired or wireless telecommunication quickly. Increase in the number of IOT devices for personal use as well as home intelligence, leads to the need for both unified control and cooperative use in recent years. Both physical and virtual things are mostly heterogeneous as well as resource based in IOT which connected with low power and the network resource. IOT services change the data into valuable information which makes the possibility of finding knowledge in real time and making a decision. The main challenges for the application and services of IOT are related to the description of architectures, protocols, and improvement in algorithms for efficient connection between objects and future internet (Yu et al., 2016).

Various organizations such as ITU-T, European Telecommunication Standards Institute (ETSI), Institute of Electrical and Electronics Engineers (IEEE), and Internet Engineering Task Force (IETF) have been defined the term IOT. But conceptually it describes as "A global infrastructure which provides intellectual services by converging context-awareness based intelligence and interacting autonomously among self-recognized things on the common information network". IOT enables the communication between things and devices with each other and provide services without human intervention. As shown in *Figure 8*, the three dimensions interworking technologies have been introduced with the help of IOT which focus on "Anytime, Anyplace, Anything communication" (Yu et al., 2016).

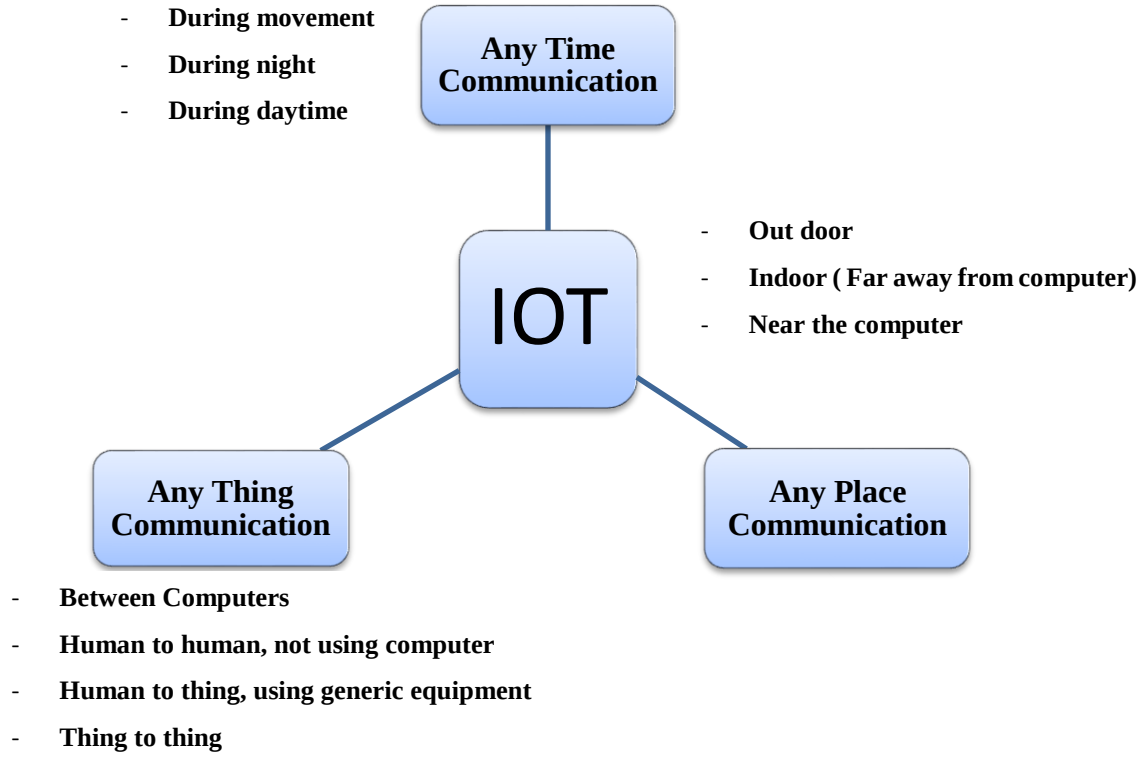

Figure 8: Dimension of IOT (Yu et al., 2016)

4.3 Elements, Architecture, Features, and Platform

The realization of IOT in the real world needs to integrate some technologies. RFID system can be introduced as an important component of IOT which contains different readers and a number of RFID tags (Finkenzeller, 2003; Atzori et al., 2010). Tags are depicted with the distinctive identifies which applied to the objects such as human and animals. The tags can be applied in both passive and active way. RFID system provides a possibility to monitor objects in real time without a physical presence in that place. Therefore, RFID system provides an opportunity to discover the real world into the virtual world. The application of this knowledge can be utilized in many different fields such as logistics, e-health, security, and other fields of this kind (Atzori et al., 2010).

Sensor networks can be named as other technologies which play a key role in the concept of IOT. The sensors can connect the real world to the virtual word and help RFID to appropriately search the status of the objects in terms of their movement, temperature, and location. Sensor networks can be applied in different fields such as environmental and

industrial plant monitoring, intelligent transportation system, e-health, and military (Atzori et al., 2010).

Identification, sensing, and communication are among the technologies which need to integrate into the concept of IOT. Furthermore, middleware is another technology which needs to use for applying IOT. The software layer or a group of sub-layers place between the technological and the application levels can be named “Middleware”. The main role of this technology is related to simplify the new development of the service and the integration of legacy technologies to new ones (Atzori et al., 2010)

The elements of IOT can be categorized into three different groups: hardware, middleware, and presentation. The first one is hardware which consists of sensors, actuators, and embedded communication hardware. Next is middleware which can be named as demand for the storage and computer devices to analyze the data. The last one is a presentation that is easy to understand visualization and interpretation devices which are able to not only accessed on a different platform but also designed for a different application (Gubbi et al., 2013).

Implementation of IOT is based upon architecture which divided into different layers such as applications layer and middleware layer in the top, internet layer in middle, and access gateway and edge layer in the bottom. As shown in *Figure 9*, the two top layers are related to data utilization in applications and the two bottom layers are about data capturing which separated by internet layer in the middle with the aim of communication between these layers. These layers are designed in ways that enable to meet the needs of various fields such as industries, societies, enterprises, governments, and etcetera. The main tasks of these layers are defined in the following (Bandyopadhyay & Sen, 2011).

Edge Technology Layer: Sensors, networks, embedded system, RFID tags, and other sensors in various forms are categorized in this hardware layer. Several elements of this hardware are able to perform different activities such as provide identification and information storage, collecting information, information processing, control, communication, and actuation (Bandyopadhyay & Sen, 2011).

Access Gateway Layer: The first stage of data handling occurs in this layer. The main activities which are done in this layer are taking care of message routing, publishing,

subscribing, as well as cross-platform communication, if needed (Bandyopadhyay & Sen, 2011).

Middleware Layer: This layer can be named as the most critical one which performs bi-directional. It performs as an interface between edge layer and application layer. The main responsibilities in this layer are device management, information management as well as be careful about a range of issues such as data filtering, data aggregation, semantic analysis, access control, and information discovery (Bandyopadhyay & Sen, 2011).

Application Layer: The major responsibility of this level is to deliver different applications to various users in the context of IOT. Application of IOT can be a benefit in different industries such as logistics, healthcare, transportation, manufacturing, retail, and to name but a few (Bandyopadhyay & Sen, 2011).

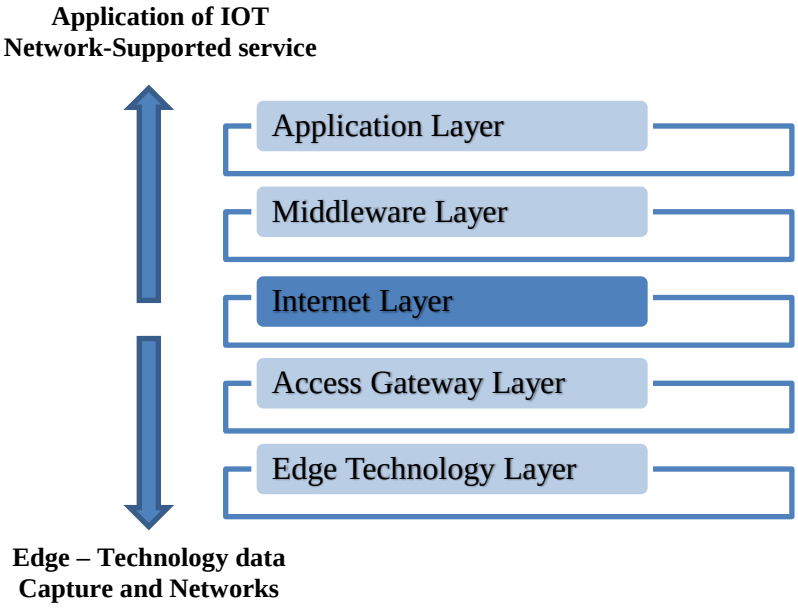

Figure 9: Architecture of IOT (Bandyopadhyay & Sen, 2011)

In order to provide the strong financial basis for IOT, considering some features for this new technology is vital. The importance attributes of the IOT divide into three groups and can be named as follows. In the first place, sensors and actuators can be named as the building blocks of the IOT which its application can be found in many different contexts and has the ability to combine in different ways. Furthermore, RFID and sensors as the components are

being continually improved in a way to provide opportunities for potential application. This technology makes the possibility of lean manufacturing and helps manufacturers to reduce the inventories and monitor required parts in real time. It helps in the management of the cities or transportation in order to improve the efficient utilization of limited resources. Secondly, IOT does not always expect to do activities with the totally new idea but acts something with the real time and precise data in compare to the previous one. For instance, police have been supported by computers many years, but the concept of IOT enables the advanced big data analytics and crime pattern to track real-time data with sensors in a large geographical scale. Finally, data sharing is a main part of the IOT. The debate of the smart cities concentrates on the integration of data among various services and sectors. Distribution of real-time data on energy use or transportation between various transportation systems, different vehicles, as well as environmental sensors can be mentioned as the examples in this regard. In china, the environmental application for monitoring pollution level, can be named as the valuable application, and create new information which does not depend on government. The importance of sharing an idea for IOT is the ability to support applications that contain the behavior knowledge. The combination of individual data turns to a large value due to the creation of new forms of collective intelligence (Dutton, 2014).

The platform in the context of IOT refers to software products that propose through groups of application that can be applied to make IOT application. Many different platforms exist for IOT according to specific requirements and application field. For instance, one group of platform concentrates on embedded applications on things like Eclipse. The second type concentrates on the particular functionality of IOT in order to complete current non-IOT platforms like Xively. The last group is the most complicated one which refers to core IOT technologies that contain all features in one IOT platform such as ThingWorx, and the Bosch IOT Suite (Wortmann & Fluchter, 2015).

4.4 Enabling and Challenging Factors of IOT

Like other technologies, IOT has many demanding problems which need to be addressed. Different challenges such as the possibility of technologies, social knots, and devices are required to be considered before the idea of IOT to be applied in a wide range of knowledge. The main concern is creating a connection with devices, making these devices smart, and

using this technology in the way that is more secure, reliable, and safe for the users (Atzori at al., 2010). Furthermore, IOT will pose new difficulties about utilizing efficient resources in low-powerful resource constrained objects (Bandyopadhyay & Sen, 2011). Energy, intelligence, communication, integration, standards, and interoperability define as the enabling technologies for the occurrence of IOT, while the absence of governance, as well as privacy and security, describe as the barriers for IOT (Santucci & Lange, 2008).

Energy gathering and low-power chipsets have been introduced as the energy challenges which are among the significant factors for IOT growth. More investigation in this area is required in order to find comprehensive energy storage such as batteries, a fuel cell, as well as printed or polymer batteries. Additionally, new devices for generating energy, joining the methods of energy transmission or energy gathering based on energy conversion are among the main factors for the implementation of independent wireless smart systems. Modern intelligent multiple frequency band antennas, and integrated on-chip are the instruments that required for device communication in IOT. The optimization in size, cost, efficiency, as well as diversity in forms, is required for on-chip antennas. Context awareness, as well as inter-machine communication, can be named as the high priorities capabilities for IOT. Integration of memory and processing power, the capacity of resistance in various weather condition, as well as reasonable security, describe as the further capabilities for IOT. The growth of designed extremely low power processors or microcontrollers cores for portable IOT devices and new kind of IOT-centric smart systems with reasonable cost, are among the enabling factors as well. Open standards can be named as the essential enablers for successful IOT. Development of IOT beyond RFID solution in universal scale cannot be achieved without clear standards like TCP/IP. Interoperability is another enabling factor for IOT. Two different devices with the same standards might not be interoperable. In other words, devices should be compatible with IOT technologies (Santucci & Lange, 2008).

Without the presence of government, a broad expansion of IOT technology which accepted by states, companies, commerce organization, and society is impossible. It needs to keep governance in generic form and having specific authority for each application that results in overlap, confusion, and competition between standards. Additionally, accessing to the broad expansion of IOT requires technical solutions for both security and privacy issues. Although security and privacy can be named as the additional features in many situations, the presence of security and privacy is needed for the general acceptance of IOT (Santucci & Lange,

2008). Consequently, lack of privacy can be named as one of the negative points of IOT. It means that all the human preferences, activities, favorite hobbies, and some other information like these become visible to artificial intelligence (Constantinescu, 2015). Therefore, the security and privacy challenges should be tackled with future standards and introduce various security characteristics with the aim of the creation of confidentiality, integrity or availability services (Santucci & Lange, 2008).

The expected sizes of billions or trillions of smart things and object, that make new social and technical issues in terms of size, are the main progress of IOT. Self-organization of network as well as autonomic management of smart things, identification of smart thing, goal-oriented behavior and context awareness, maintenance and diagnosis, and intrusion of the privacy are among the challenges. The introduction of the low power wireless communication provides opportunities to contact with smart things without any connection devices. The portable smart things have the ability to change its place throughout the world with retention of identity. The broader reliability of signals from the universal system enables a smart things awareness of time and place, and propose services according to the existing context to use (Yu et al., 2016).

There is a need to tackle with technological challenges as well as social knots before the global acceptance of IOT idea. Important challenges make the possibility of complete interoperability of connected things or devices. These created with the steady high level of intelligence by enabling independent as well as adaptation behavior while privacy assuring trust and privacy. Moreover, the concept of IOT increases and creates various inter-network issues. A small amount of resources and power in terms of energy capacity, as well as calculation, is required in the things or devices that use in IOT. Consequently, apart from resource effectiveness, the availability, as well as scalability issues, required special consideration for the proposed solutions. But the technology of IOT has the ability to enhance the role of ICT as innovation enabler in different services as well as application markets (Yu et al., 2016).

A continues policy with the technology is an obligatory activity for the IOT concept according to its impacts on the people’s confidence and acceptance. For instance, the introduction of electronic health cards faced with public rejection due to the possibility of

information misuse. Therefore, RFID tags might encounter with the same public resistance because of the probability of temporary disablement (Santucci & Lange, 2008).

On the other hand, education and information can be named as significant aspects for IOT success. There is a need to educate people about the advantages of IOT and its potential use, and improve the privacy technologies. Moreover, access to information about the existence of RFID tags, the range of reading, support system, and the type of data in devices should be possible easily for people (Santucci & Lange, 2008).

Society and culture can be named as two significant factors for the public acceptance towards novel technologies, especially IOT. European people pay too much attention to the privacy and refuse to accept the technology without control and surveillance, while a large group of people in America accept the surveillance and authority control to improve both personal and national privacy. Consequently, IOT should meet societies' expectations and requirements for successfulness (Santucci & Lange, 2008).

Global system for mobile communication (GSM) can be named as one of the huge success happening in wireless technology for Europe. The ability of European organizations and industrial to collaborate via common standard with global acceptance has been shown in GSM. This ability has turned to the strength factor for Europe against current issues. Some examples can be stated in this regard. Firstly, various cultural histories lead to the fair treatment of privacy and security problems. Two European characteristics such as the capacity of understanding various situations, as well as steady attempts for the universal acceptable agreement can be named as the enablers for providing fair balance to address both security and privacy issues. Secondly, based on leading regulation on data protection, EU-conceived standards are more advanced and have many possibilities to be agreed by a vast number of people and more regulation-compliant in compare with other standards which developed around the world with various purpose and common sensitivity. Thirdly, ETSI as ,the leading European organization around the world, and Airbus as ,an industrial consortium, can be named as the two top-quality organizations in Europe that proved the high production capacity of bilateral collaborative results successfully in the past. These factors are extremely important to make sure the diversity and appropriate governance of the IOT (Santucci & Lange, 2008).

4.5 Application Domains

IOT has many applications which can be applied in our societies. The vast majorities of these applications can help to improve the quality of our lives and facilitate our life in many different situations such as home, office, during traveling, jogging, exercising, and et cetera (Atzori et al., 2010). The application of IOT can be categorized based on many different aspects such as the type of network availability, coverage scale, heterogeneity, repeatability, user involvement, and impact (Gluhak et al., 2011; Gubbi et al., 2013).

The application of IOT can be divided into four groups: transportation and logistics, healthcare, smart environment, and personal and social (Atzori et al., 2010). In the field of transportation and logistics, by the use of modern cars, buses, trains, bicycles, and other types of transportation which equipped with sensors, RFID tags, actuators, and processing power, activities such as controlling traffic, diagnosing better or shortest routes, appropriate management of depots, providing useful information for tourist, and monitoring the status of the transported products, can be achieve from IOT concepts (Atzori et al., 2010).

The domain of transportation and logistics can be categorized in different filed. Logistics, assisted driving, mobile ticketing, environment monitoring, and augmented map can be classified in transportation and logistics domain. In the field of logistics, the technologies which exist in IOT, provides opportunities for the supply chain to monitor every step of the products or services from commodity design to after-sale service in real time. In the field of assisted driving, vehicles are equipped with sensors, RFID tags, actuators, and processing power which provide an opportunity for better navigation and safety. Moreover, authorities can benefit from IOT by achieving accurate information about road traffic patterns, traffic jam, and incidents. Freight companies can get benefit from the information such as delivery time, delivery delay, the status of the goods, and faults in their business which results in saving more energy and increase the efficiency. In the field of mobile ticketing, passengers, travelers, and individuals, individuals can get useful information by mobile phone automatically from the web service about the stations, a number of passengers, available time, costs, available seats, and type of services (Broll et al., 2009; Atzori et al., 2010). In the field of monitoring environmental parameter, the technology of IOT provides information which helps to improve the quality of food supply chain. For instance, it would be possible to monitor the status of the food especially the food which is likely to decay

quickly from production until delivery and transportation by this technology (Ilic et al., 2009; Dada & Thiesse, 2008). In the field of augmented maps, by the use of IOT technology, tourists' maps can be equipped with tags, which help them to provide information about the hotels, restaurants, historical place and other things according to the place where the user located (Atzori et al., 2010).

Next application of IOT is related to health care domain. Healthcare domain has divided into four categorize. Tracking, identification and authentication, data collection, and sensing are among the resulting applications of healthcare domain (Atzori et al., 2010). In the field of tracking, the main aim is to identify the movement of a person or objects. Tracking of movement through checkpoints in real time and right location can be named as the application of tracking in the field of healthcare. Material tracking in order to prevent left-ins throughout surgery like sample and blood products, and maintenance can be named as the example of tracking in healthcare. In the field of identification and authentication, the likelihood of wrong drug, dose, time, and procedures can be reduced by the use of this knowledge. For instance, modern medical devices can record patient information in order to prevent infant diseases quickly. By the use of IOT technology, it would be a possibility for the doctors to monitor patients' health condition in their home which results in decreasing hospitalization costs by on time treatment (Luo et al., 2010; Nussbaum, 2006). In the field of data collection, by the use of IOT knowledge, automated data collection results in accelerated processing time, automated care, procedure auditing, and medical inventory management. Sensing is the last resulting application of healthcare. By the use of sensors, it is possible to diagnose patients' health conditions, providing information about the patients' compliance with their prescription, monitoring patients' wellbeing, and providing real-time information about patients' health conditions (Niyato et al., 2009; Atzori et al., 2010).

Smart environment domain is another application of IOT which categorized in three results such as comfortable homes and offices, industrial plants, and smart museum and gym. IOT can provide comfortable homes and offices for people. Providing rooms heating according to users' preferences and weather, fitting rooms lighting according to user's preferences or the time of the day, preventing from a domestic accident by the use of intelligent alarm and saving energy can be named as an example of IOT (Buckl et al., 2009). The smart manufacturing makes the production line more intelligent. For example, in the case of emergency, this technology can stop the operation. The status of the products and devices,

the production progress, as well as the place of the bottleneck can be monitored by the use of IOT. In the smart leisure activities such as exercising or visiting the museum, the technology of IOT can be applied very much. For instance, by the use of this technology sportsman can get more information about their body status, or their exercise program can be uploaded in their exercise profile. In the museum, this technology can provide the condition which helps to create the historical place more real like changing the weather condition (Atzori et al., 2010).

The last application of IOT can be seen in the personal and social domain. Social networking, historical queries, losses and thefts, can be classified in this domain. In the field of social networking, IOT technology enables interaction with other friends and provides the possibility to real time update of personal information automatically. Moreover, the users can control their friend's list and what events are revealed with which friends. The historical query is another application of IOT which enable individuals to review their memories as well as the people who you are with and in which place. Furthermore, it is more useful for supporting long-term activities like collaboration and different projects. IOT can also be applied by the use of last recorded location and search engine to find the belongings which are lost or leave somewhere you don’t remember. The previous technology can be applied for arresting the thefts (Atzori et al., 2010).

All the applications which mentioned above are implemented currently. Futuristic application domain relays heavily on the technology that is not implemented yet or the complexity is still too much. Robot taxi, city information model, and enhanced game room are among these applications which will apply in the future (Atzori et al., 2010).

Future life will witness of robot taxi which can move in and provide services in exact time and efficient way. It would be possible in the future to answer to real-time traffic movement of the city, to reduce traffic congestion at bottlenecks in the city and the pick-up service which provided in the area that used frequently. The robot taxi will be able to drive with or without drivers at optimum speed and avoiding an accident. Moreover, people either can use their mobile or shake their hands to inform the robot taxi (Atzori et al., 2010).

The main concept of city information model focuses on the performance or status of the building and urban fabrics observing by the government continuously, and become available for third parties via the group of application programming interfaces (APIs), as well as the

information that is confidential. This application provides an opportunity for the construction that the new construction will happen according to the law in the case that it will be compatible with city information model. Energy saving, sharing energy effectively in terms of cost and resource fashion, and calculating to create a match between demand and supply are among the main advantages of this application (Atzori et al., 2010).

The enhanced game room will be equipped with a vast majority of tools which susceptible of humidity, temperature, noise, acceleration, movement, location, visual information, as well as health condition such as blood pressure and heart rate. The information can calculate the feeling of excitement and the level of energy in order to control the activity according to the condition of the person. In the case of lack of convenience for the players in their position, the system is able to change the position automatically according to the users' preferences (Atzori et al., 2010).

5 IOT IN DISRUPTIVE INNOVATION FOR SUSTAINABILITY

The significant role of the disruptive innovation in creating new market value cannot be neglected in technology management studies. New market value can be created by disruptive innovation in unexpected ways; independently and hybrid with current standards and protocols. Technology convergence can be named as the method that results in disruptive innovation. For instance, Skype, defines as a disruptive innovation which happens with the merging of two various technologies such as voice over internet protocol (VOIP) and peer to peer (P2P). Skype introduces as the fusion strategy with a P2P based VOIP software that leads to audio quality which is compatible with standard phone lines. P2P technology offers various services including immediate messaging, communication facilities, as well as files sharing utilities, and distributed computing which in this case the main focus was the perfect quality of voice service and different sets of value added utilities with the feasibility of lowest costs. The founder of Skype represents an original tool that creates discontinues innovation and a new form of market value with considering the novel performance criteria in certain niche market settings (Rao et al., 2006).

On the other hand, the introduction of internet has been changed the accessibility of information, people, services, and technologies. IOT adds another room for this revolution by embedding RFID tags, sensors, and actuators in objects. These objects with the help of IOT technology can connect with standard IP, phones, cars, and other devices with the ability to contain more information with them, and exchange information with each other. It is expected that these devices will be the main part of the structure of smart cities, intelligent energy service, transportation networks, logistics, health and medical care services, household, and other domains in the future. IOT connects with a wide range of networked economies and societies which require both the social and organizational innovations, as well as innovations in information and communication policies and regulations (Dutton, 2014).

Need for sustainability and a universal increase in product demands and manufacturing activities are among the two trends which lead to representing strategic technologies for reduction of environmental effect which created from production. For instance, companies can create enormous improvement for resource productivity by energy efficiency actions, remanufacturing, and material reuse, as well as offering disruptive technologies and

solutions for the fast improvement in global market including clean tech investment, which supports carbon smart manufacturing. The solutions for environmental actions are generally based on product and process focus. The product concentration is based on product with less environmental effects while the process factor is related to the production methods with less impact on the environment (Wiktorsson et al., 2008).

IOT by the use of embedded sensors, processors, and communication technology enables extraction of smartness from physical world which leads to healthier life, safer cars, smarter homes and cheaper maintenance, efficient companies and farms as well as an eco-environmentally place to live (Smith, 2015). Furthermore, Green IT provides opportunities to produce and deliver novel products or services and make the possibility of sustainability initiatives. The strategy of Green IT can range from cut IT infrastructure's carbon footprint to transformation in business. The concept of "Green IT" improves sustainability performance by the use of carbon footprint measurement, observing the environmental effect of business, waste cuts in the business procedure, reduction of resource usage, improve energy efficiency, as well as cutting greenhouse gas emissions (Mohan et al., 2012).

5.1 IOT as a Value Creation for Sustainability

According to the statistical information, provided by CISCO (Evans, 2011), the number of connected things exceeded the amount of people existing throughout the world and will reach 50 billion in 2020. This amount of connected device changes the world to the rich digital environment by embedded sensors, cloud infrastructure, smart fixed, and portable platforms including smartphones, tablets, as well as home gateways which are created in order to provide value to different sectors (Kyriazis & Varvarigou, 2013).

Sustainability argument including energy saving, renewables and material recovery, legislation such as eco-design instruction as well as implementing directives for waste treatment, and the major role of networks especially IOT are among the drivers for companies which provide a competitive place in the industry (Siemieniuch et al., 2015).

The ability to trace the objects in every time and location during lifetime will result in sustainability, development, and unique identifiable (Atzori et al., 2010). Sustainability in IOT technologies requires the method to change the performance of devices and objects to

be more reliable, tough, autonomous, as well as smarter. Mechanisms for assuring the security, trust, as well as protected privacy are required for sustainable IOT applications. Achievement to these factors needs not only the low level of IOT society e.g. hardware-coded methods but also the management of data and application levels. In order to access to sustainable IOT application, many challenges such as tamper-evident smart devices, dynamic and trust models, secure data storage, as well as application with security and privacy are critical (Kyriazis & Varvarigou, 2013).

IOT technology enables objects and things to be smarter which lead to cost savings and efficiency increases. Therefore, these have additional value for the city and result in continuous economic development. Efficient management of various numbers of objects, as well as optimization in energy and resource consumptions, are required for sustainability which can be achieved by the use of IOT technology. Furthermore, it is needed for development of technologies to manage all the available objects with various contexts, applications, environments, administrative domains, as well as locations. In addition to this, in order to have tough and smarter things in smart cities, it is require considering adaptability of services and ICT systems with IOT application requests and real world occurrence while assessing the lifecycle of these applications (Kyriazis & Varvarigou, 2013).

In order to provide a group of technical innovations to work for digital economies and societies, understanding of technologists, policymakers, and previous ideas about the possible social and policy challenges, which created by the various application of IOT, is required. By the development of the right practices, policies, and business models, IOT makes the possibility for serious social, economic, and service innovations in the following development years. Networked digital economics provide opportunities to utilize the potential of IOT innovations in different sectors and turn them to a ubiquitous attribute (Dutton, 2014).

As a result, the companies with the right outlook who utilize the IOT platforms have the possibility to present great opportunities in different domains such as novel service offering, better asset performance, better operational efficiency, and novel way of representing value to customers (Sundaram & Gorbach, 2015). *Table 3* illustrates the applications and actors in IOT services and shows in which dimension of sustainability value has been created (Dutton, 2014).

Table 3: Applications and actors in IOT services (Dutton, 2014)

Type of application	Device	Sustainability Dimension	Third party data users
Monitoring and managing energy use	Smart energy meter reading	Environmental, Economic	Government agencies, news
Remote monitoring for disease	Sensor, webcam, microphone	Social	Other members of household
Environmental monitoring	Smartphones, pollution apps	Environmental, Social	Government agencies, press
Health monitoring	Smartphone apps or email	Social, Economic	Insurance companies, pharmaceutical companies
Tracking	Tracking device	Social	Insurance companies
Logistics management	Tracking device, GPS	Economic, Environmental	Transportation planner, freight carriers
Manufacturing	Sensors, RFID	Economic, Environmental	Customers, contractors
Quantitative self: running, jogging and personal data	Smartphone app	Social	Local governments, press, planners, other individuals
Location, travel direction	Sensors, RFID	All three dimension	Transportation planner, law enforcement

5.1.1 Impact of IOT on Social Dimension of Sustainability

IOT will provide a comprehensive revolution in compare with the internet, mobile technologies, and current information era. The privilege of IOT will provide opportunities to exchange information via virtual objects and devices and improve the guilty of life (Santucci & Lange, 2008). For instance, the concept of the smart city provides an opportunity to have a unique framework for the sustainable society based on state-of-the-art technologies. Smart cities provide cooperation between ubiquitous sensing technology and its social components with the aim of improvement in the quality of life, as well as the maximum efficiency of the city services. Smart cities create a society which attaches technology in every part of the city. Therefore, various forms of services can produce for citizens with the help of interconnected information and capabilities of this technology. IOT technology shifts the way to solve the incidences related to the citizens. Therefore, In order to provide positive shifts in peoples' lifestyle, the involvement of the citizens from the first stage of the smart cities implementation is required (Gutiérrez et al., 2013).

Individuals can benefit from the concept of IOT in their private life. For instance, the smart clothes with smart fabrics will create appropriate temperature according to users' preferences

in different places (Santucci & Lange, 2008). In addition to this, the clothes which equipped with RFID tags not only provide information about the clothes in terms of color, material, as well as appropriate washing program, they make a real-time information about the location and status of the owner. Advanced washing system, which equipped with RFID tags and readers in different parts such as clean clothes shelves, dirty clothes containers, as well as a washing machine, can recognize dirty clothes among the clean ones and not only wash but also iron them automatically (Tao et al., 2016). On the other hand, IOT can provide an opportunity for old people to have a comfortable independent life. Wearable and ambient sensors enable many different activities including recognition of daily activities, observing social interaction, as well as observation and recognition of acute diseases (Bandyopadhyay & Sen, 2011). On the other hand, with the connection of IOT technology with security devices including camera, infrared detector, smoke detector and alarm clock, the security of the family will promote in the house (Tao et al., 2016).

IOT will provide many different intelligent traffic services such as smart parking service, citizen participation-oriented illegal parking prevention service as well as smart secure crosswalk services for the pedestrian. Smart parking service, enables convenient parking and stop unlawful parking activities. This smart parking system is based on the platform that makes the possibility of a real-time check for the available place and price of each location. It is also possible to reserve the parking place by computer and smartphones. By the use of citizen participation-oriented illegal parking prevention service, every people especially the ones who are the victims of illegal parking can report the unlawful parking with their smartphones easily. The smart secure crosswalk service provides more facilities for both pedestrians and drivers to prevent from the accident (Byun et al., 2016). BMV developed smart informatics system with the name of iDrive which equipped with different types of sensors and RFID tags with the capability of environment monitoring and showing driving directions for drivers (Qin et al., 2013).

Smart education service can be named as another application of IOT which enables real-time, as well as interactive high-quality lectures through high-quality service, and broaden area internet infrastructure. There will be a possibility of access to any educational events around the world via IOT technology (Byun et al., 2016). Furthermore, smartbooks will have interaction with entertainment module and provide more information during usage in real time (Santucci & Lange, 2008). Moreover, the technologies of RFID and barcode readers

enable the users of the library to check the availability of books by smartphones in an automatic manner (Dutton, 2014).

IOT will create the vast number of values in the medical and healthcare industry which leads to social sustainability. The technology of IOT enables utilizing cell-phone with RFID-sensor abilities as a platform in order to observe the medical parameters and medicine delivery of the patients. This technology makes the advantages of prevention and recognition of illnesses in short time as well as create fast medical attention in case of incidents (Dutton, 2014; Bandyopadhyay & Sen, 2011)**.** Moreover, the history of the patients can be stored to observe the trend of the illnesses especially for the ones who suffer from the diseases such as diabetes, cancer, coronary heart disease, stroke, and chronic obstructive pulmonary disease, cognitive impairments, seizure disorders and Alzheimer's disease. IOT technology will make the possibility for the chips which are edible and biodegradable to be defined into the human body in order to do guided activities. The persons who are incapable of moving part or entire of their bodies can restore movement function with the help of having an access to muscular stimuli delivered via an embedded smart thing-controlled electrical simulation system (Bandyopadhyay & Sen, 2011).

As the importance of security and safety cannot be neglected in the pharmaceutical industry, the concept of IOT with RFID tags and sensors improve the safety and security of the patients in a way that attaches the smart labels to medicines in order to track and observe the status of the medicines through their supply chain. For instance, the type of the medicines which need special maintenance condition can be traced and observed or even throw away in the case of inappropriate transportation condition. Moreover, patients can receive more value with the small labels on the medicines including achieving more information about package insert, dosage of the medicines, probable side effect, expiration date, as well as the standard quality of medication, and set reminder to take the medicines at accurate time while the patient compliance can be observed (Bandyopadhyay & Sen, 2011).

Customers can get more value from RFID tags during purchasing. By the use of IOT technology, not only waiting in long lines for check-out is not needed and the health of the food can be checked base on the information provided for the food history but also guiding a person to a pre-selected shopping list, detection of potential allergy in selected products, as well as marketing based on personal interest and confirmation of the cool chain will be possible (Bandyopadhyay & Sen, 2011). Moreover, with the help of tracking identities, the

customers can verify the products' sources and assists Europe to protect agricultural diversity as well as rural lifestyles (Santucci & Lange, 2008).

IOT with the help of recognizing fake products or services faithfully can provide value in aerospace and aviation industry in order to develop safety and security of products, as well as services. For instance, the aviation industry can be easily harmed or hurt to the problem of suspected unapproved parts (SUP). SUP is described as an aircraft section that is not under the guarantee to fulfill the requirements of an approved aircraft. SUP has the high importance because of its effects on the security standards of an aircraft. According to the aviation authorities report, fake information can be named as the cause of at least 28 accidents in United State. Apart from this fact that analysis of the material takes a long time to do, checking the real or true quality of aircraft sections, can be conducted by a document which has the possibility to easily counterfeit. The problem of this kind can be solved with the help of IOT. With the introduction of the electronic background of true classification of aircraft sections, there is a possibility to document the source and safety-critical happening among the lifecycle of the aircraft. This information about the background of the aircraft sections has been stored not only in a decentralized database but also within RFID tags which are attached to aircraft sections in a way that is more safe and secure. Additionally, these stored data can be checked with digital signature and make comparison between the RFID tags and databases which provide an opportunity to check before installing in an aircraft. Therefore, safety, security, and reliability in aviation industry which can be stated as the main factor for human quality of life, as well as social sustainability, will improve with the help of RFID tags and smart electronic information (Bandyopadhyay & Sen, 2011).

5.1.2 Impact of IOT on Economic Dimension of Sustainability

IOT has been turned to an important topic in recent years, and consortia have been established in order to describe standards and framework for IOT. Many different organizations try to introduce different products and services according to IOT concept. The IOT has been admitted by many practitioners and politicians due to its nature for providing real business opportunities. IDC predicted that IOT will increase market value to $7.1 trillion by 2020 (Wortmann & Fluchter, 2015). Notable cost savings and environmentally friendly products can be achieved via the integration of smart devices into packaging or products

(Santucci & Lange, 2008). Moreover, IOT opens up unlimited opportunities for digital industries and manufacturing industries, as well as sectors of the whole economy. Furthermore, some emerging business models such as lean manufacturing which uses environmental sensing rather than health monitoring are existed to support the IOT for cost savings (Dutton, 2014).

The term Industrial Internet of things (IIOT) refers to the introduction of modern connectivity in industrial area. IIOT creates more competitive values such as innovations in intelligent products, novel service and operating models, novel production methods, and new procedures for design and sourcing. According to Karthik Sundaram, who is the senior research analyst at Frost & Sullivan, "IIOT has the potential to disrupt supply chains, increase production efficiency, expand customization capabilities, and reduce lead times significantly. The gains from a quantitative standpoint will vary from one industry to another and will also depend on the level of investments an end user is willing to make." Implementation of IIOT in mid-size manufacturers leads to at least not only 30% growth in productivity but also 25% development in financial benefits particularly in terms of operating expenses (Sundaram & Gorbach, 2015).

In the domain of manufacturing industry, the manufacturing process can be improved and the whole lifecycle of the production process from the production to disposal can be observed through linkage of items with information technology. RFID tags in items and containers create the possibility of gathering right and real-time information about the status of the shop floors, the place and temperament of the goods, as well as the condition of the production machines which leads to economic sustainability during manufacturing (Bandyopadhyay & Sen, 2011).

In the domain of agriculture industry, IOT with the help of wireless sensor networks technology enables precise and real-time information collection about the quality of soil, atmospheric condition and other information of this kind in order to have scientific cultivation and forecast, as well as accurate control. IOT in this industry not only helps to access to high level of data accuracy and save a large amount of labor power, it promotes the efficiency, as well as the quality of agricultural production. For instance, IOT makes the possibility of an increase in the production of vegetables and fruits with controlling action on micro-climate condition and quality. Furthermore, the amount of sugar in vine, as well as

the health of the grape, can be controlled by observing the level of soil moisture and diameter in vineyard garden with IOT technology (Tao et al., 2016).

In the domain of transportation industry, IOT will propose many solutions including smart fare collection and toll system, automatic boarding checks for passengers and goods in order to improve the demand for safety and security around the world. Moreover, observation of traffic congestion with smartphones and growth of intelligent transport systems leads to efficient transportation service. Self-scan and automatic weight measurements are among the activities which could be possible with the help of IOT for transportation companies (Bandyopadhyay & Sen, 2011).

IOT has the ability to provide many different benefits in the domain of retail, logistics, and supply chain management. In the retail industry, the products will equip with RFID tags, stores will equip with smart shelves, and retailers can achieve more value by searching real-time information. Moreover, the example of value creation by IOT in the retail industry can be named as the smart approved of goods receipt, real-time observing of stock, and searching among stocks, as well as the detection of robbery while IOT can create major savings potentials. Additionally, the intelligent shelves enable automatic refill in storage and offer accurate delivery service from the wholesalers to the storage. The quality management will improve through the historic information about the products from the production to shelves as well (Santucci & Lange, 2008). In the domain of logistics, the help of IOT for the provision of data from retail store leads to the optimum use of the logistics throughout the entire supply chain. Having right information about the stock and sell product from retailers, results in the shipping and production of the right amount of products by manufacturer. Therefore, manufacturers don’t face with over production or under production (Bandyopadhyay & Sen, 2011).

An insurance company with electronic recorders in the car, enables to record speed, acceleration, and other parameters of the car. The car insurance proposes reasonable rate or premium according to the recorded information. Therefore, the person who uses this smart system can save money by taking action in the early stage of impending incidents. The IOT technology not only can prevent the large-scale maintenance operations, it permit to the low price predictive maintenance before its occurrence (Bandyopadhyay & Sen, 2011).

5.1.3 Impact of IOT on Environmental Dimension of Sustainability

The solutions, which created by IOT, have the ability to provide competitive advantages in many different fields such as smart building and homes, smart cities, healthcare and surveillance, as well as smart business and product management. For instance, the technology of IOT provides a novel generation in decision making and monitoring system. Sensing technology is another example which enables environmental safety and danger detection. Moreover, with the help of IOT, there is a possibility to enhance the safety and reduce the number of disasters (Yu et al., 2016).

The application of sensors can be found in different places. For instance, sensors can be utilized for turning the light off and on automatically. Sensors can be used in rivers to observe the pollution. Moreover, by the use of mobile phone the accessibility of real-time data about different issues is possible. It is estimated that sensors have been embedded in the tens of billion devices among the world (Dutton, 2014).

On the other hand, the sensing technology will prevent the occurrence of catastrophes and allow early alarm. For instance, with the knowledge of sensor, an open gas valve can be recognized quickly and the possible pollution in water will be detected by embedded sensor in the drain. The presence of IOT technology will offer fast monitoring and control, as well as cost-efficient responses. Moreover, IOT will decrease the environmental effects of used products and play a vital role in product lifecycle management. As a result, the concept of IOT enables detection, control or prevention of natural disaster, and the hazardous situation quickly (Santucci & Lange, 2008).

Sensor technology will make the possibility of optimum energy control. The temperature and light of the house can be adjusted according user's preferences. Adjustment of interior temperature will be happen with less energy and proactive control by the use of sensory information. Therefore, the needs for huge investment in advanced grids and new power plants will decrease in this way (Santucci & Lange, 2008). Moreover, IOT can propose useful information about saving money and energy by observing the status of the energy and water supply consumption (Tao et al., 2016).

Resource efficiency, as well as pollution, and disaster avoidance, can be named as the main environmental aspects of IOT. Energy preservation can be introduced as a prerequisite item for IOT. The idea of "energy harvesting" makes the possibility of generating a considerable

portion of the used energy with the help of ambient renewable sources available nearby. Therefore, “energy harvesting” leads to the reduction in energy losses in long term period. Furthermore, the energy sources of the vehicle can be changed to the more eco-friendlier one. For instance, electrical cars will achieve longer range and turn to the most attractive alternative in compare with fossil fuel vehicles (Santucci & Lange, 2008).

In the domain of logistics, existence of IOT does not mainly change the industry but it provides features with additional value and enhances the process efficiency. With the concept of IOT, automatic warehouses will create, and it facilitates the arrivals and departures of the products, and orders will send to the suppliers without human intervention. In this way, better asset management as well as proactive planning will occur by the transporters. The automatic transportation from manufacturers to customers, as well as direct response about market requirements will provide by the use of IOT technology. These items will create values and enable time, money, and energy savings, as well as clean environment (Santucci & Lange, 2008).

With IOT technology, the devices will be smart and could act based on a set of predefined actions. It enables intelligent decision making based on changes according to consumer preferences. For instance, the smart building could reduce energy usage and promote comfort. The intelligent car can be named as another example which enables safer and pleasant trip for both drivers and passengers with the aim of environmental protection as much as possible (Santucci & Lange, 2008).

The impact of IOT can be found in automotive industry vividly. Many different public and private vehicles including cars, trains, buses, and bicycles will turn to smart transportation devices based on embedded sensors and RFID tags. These advanced vehicles with embedded sensor can utilize the smart thing in order to observe and report the status of the parameters in tires, engine power, fuel consumption, and other useful information about related vehicle. The technology of RFID has been utilized already in order to simplify vehicle production, enhance logistics, improve quality control, as well as enhance the quality of customer services. RFID tags attach to the parts of the product which encompass the information of the product in terms of the construction date, producer, code, type, serial number, as well as current location. It is possible to access to real-time data with RFID technology in different part of the companies such as production process or maintenance operations while it

proposes the new methods to manage recall in more effective way (Bandyopadhyay & Sen, 2011).

Literature review on the high influence of incidents in chemical and petrochemical industries in the UK, illustrates that the main cause of accident is related to the lack of knowledge, poor level of management in storage, process and chemical segregation. IOT provides capabilities via equipped containers with smart wireless sensor nodes to decrease the number of incidents in the oil and gas sectors (Bandyopadhyay & Sen, 2011).

In the field of product lifecycle energy management, which contains three phases including design, production and service, utilization of IOT technology in the entire lifecycle of the product, leads to have an efficient energy management. For instance, IOT enables a large amount of data gathering, as well as data analysis in design phase which leads to the possibility of LCA, simulation, and testing products based on the real situation. Simultaneously, with the help of data transferring from IOT platform, the optimum procurement in terms of raw material is possible during this phase. In production phase, with the help of accurate real-time data gathering, and better observation and control of the complex production procedures, IOT provides more advantages such as cutting energy usage in public facilities, as well as controlling manufacturing tools and workpiece. Extremely efficient transport scheduling thorough user guide for energy consumption, predictive and helpful maintenance, and precise categorization of retirement, as well as disposal action, can be named as the activities which cannot be possible without the IOT technology during service phase (Tao et al., 2016).

5.2 Development of Circular Economy Performance with IOT

Gradually CE has been getting the place of linear model among industries because of the environmental issues, as well as resource scarcity that the human beings faced in recent years. The logic of CE makes us to pay the same attention to reverse as forward flows of material. Moreover, compared to forward flow of linear model, CE needs attention to the relative immaturity of the systems of products, as well as material qualifications, which continuing in reverse direction. Although such systems are relatively immature, they have a vast number of demands because of the entropic nature of production, distribution, and

consumption process (Spring & Araujo, 2016). Consequently, the main aim of CE is to make the possibility of effective flows of materials, energy, labors, as well as information with the ability of rebuilding natural, as well as social capital (MacArthur & Waughray, 2016), while always remaining materials, products, and components at their highest level of utility and value (Spring & Araujo, 2016). In fact, the privilege of CE needs physical action rather than economic points (Andersen, 2007). Moreover, Because of the high importance of sustainable energy supply, CE helps to enhance not only the national security, but also the positive environmental impact which leads to both overall well-being and modernization in the society (Su et al., 2013).

On the other hand, technology can be named as a crucial factor for growth in CE. High-tech development and sophisticated technology, as well as updated facilities and equipment, are required for every principles of CE (Su et al., 2013). IOT technology has been defined as the phenomenon, which has the potential and enables to observe constantly, adjust as well as redefine the products and their relationships with other actors and objects in a network. The concept of IOT provides opportunities to create connected prosperous biographies of products which results in going down to particular elements and parts that have the possibility to utilize in many different ways. IOT enables data availability for companies in order to plan appropriately and provide routine maintenance for deployment of service capabilities. For instance, connected product will present opportunities for maintenance with smart management of spare parts (Spring & Araujo, 2016).

According to Janine Benyus (MacArthur & Waughray, 2016), who is the co-founder of Biomimicry Institute, the combination of IOT and CE practices provides enormous opportunities for both business and society in large scale. Moreover, utilization of IOT in CE leads to having systems which are resilient, decentralized, self-repairing as well as scalable without existence of complicated issues. Additionally, the technology of IOT will provide more information about the availability of the resources or losing resources at the company. Improvement in tagging and tracking technologies leads to immense economic opportunities in order to fill the gaps and make the possibility of using material which has been considered as a waste previously. Furthermore, Tim Brown, who is the Chief Executive Officer of IDEO, believes that real CE cannot be possible without IOT. Moreover, sustainability in system needs reacting quickly, while action as well as behaviors should be connected with each other via data and knowledge. The existence of systems with the ability

to adapt and react to shift in a way that the purpose remains fit can be happen with embedded intelligence in objects (MacArthur & Waughray, 2016).

The concept of CE is coevolving with the technology of IOT. This technology enables broaden internet connectivity not only between people but also between objects which leads to creating as well as gathering a large amount of data in different domains. “Smart, connected products” has been named for this phenomenon by Porter & Heppelmann in 2014. Smart, connected products encompass with three main constituents including physical components, smart components as well as connectivity components. Physical components consists of mechanical and electrical parts of the products, while smart parts encompass the sensors, microprocessors, data storage, controls, software as well as advanced user interface and embedded operating system. Moreover, connectivity includes ports, antennas, and protocols with the possibility to connect with or without wire to the products. Smart components boost the abilities and value of the physical components, whilst connectivity bolsters not only the abilities and value of the smart components, but also makes the possibility of the existence of some functions of the products outside the physical devices (Porter & Heppelmann, 2014).

Combined lenses of smartness and connectivity will open the room for completely new groups of product functions and capabilities including monitoring, control, optimization, as well as autonomy. *Figure 10* illustrates the capabilities of the smart, connected products which each of these capabilities sets the stage for the following level (Porter & Heppelmann, 2014).

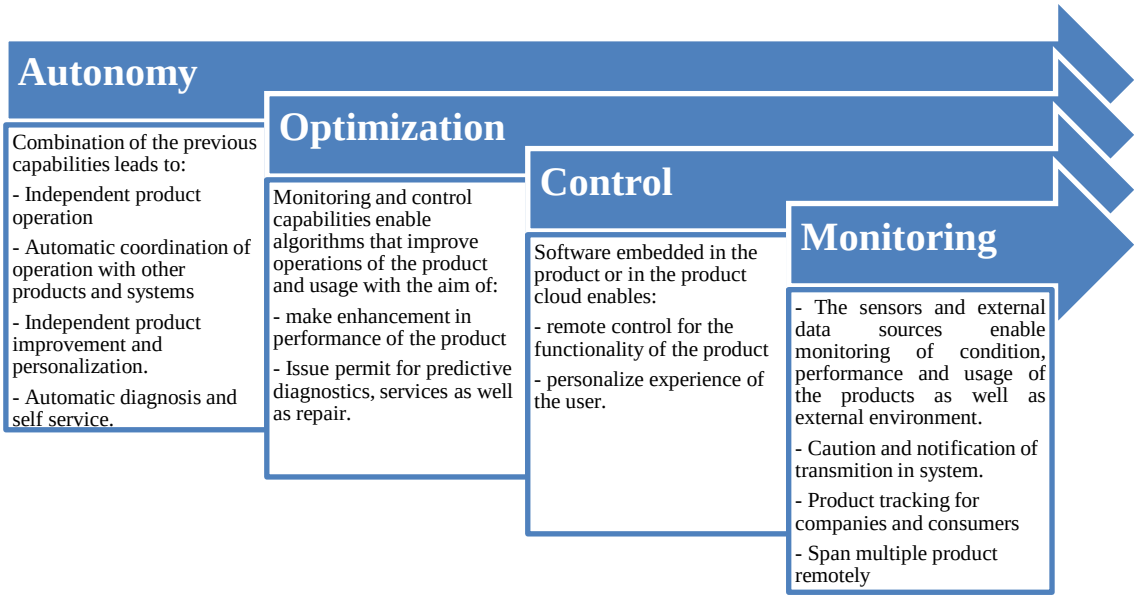

Figure 10: Capabilities of smart, connected products (Porter & Heppelmann, 2014)

The application of intelligent system can enhance the performance of the system in different domain especially production and resource lifecycle by precise traceability, better quality management as well as an optimization in recycling. For instance, with the help of the intelligent system, access to the history of the system for restoring in case of maintenance, dismantling as well as recycling problems are possible (Thomas & Trentesaux, 2014). According to the new technology stack, which has been shown in *Figure 11*, technology stack consists of many different layers such as product cloud, connectivity, product, identity, and security, as well as external information sources, and integration with business systems (Porter & Heppelmann, 2014).

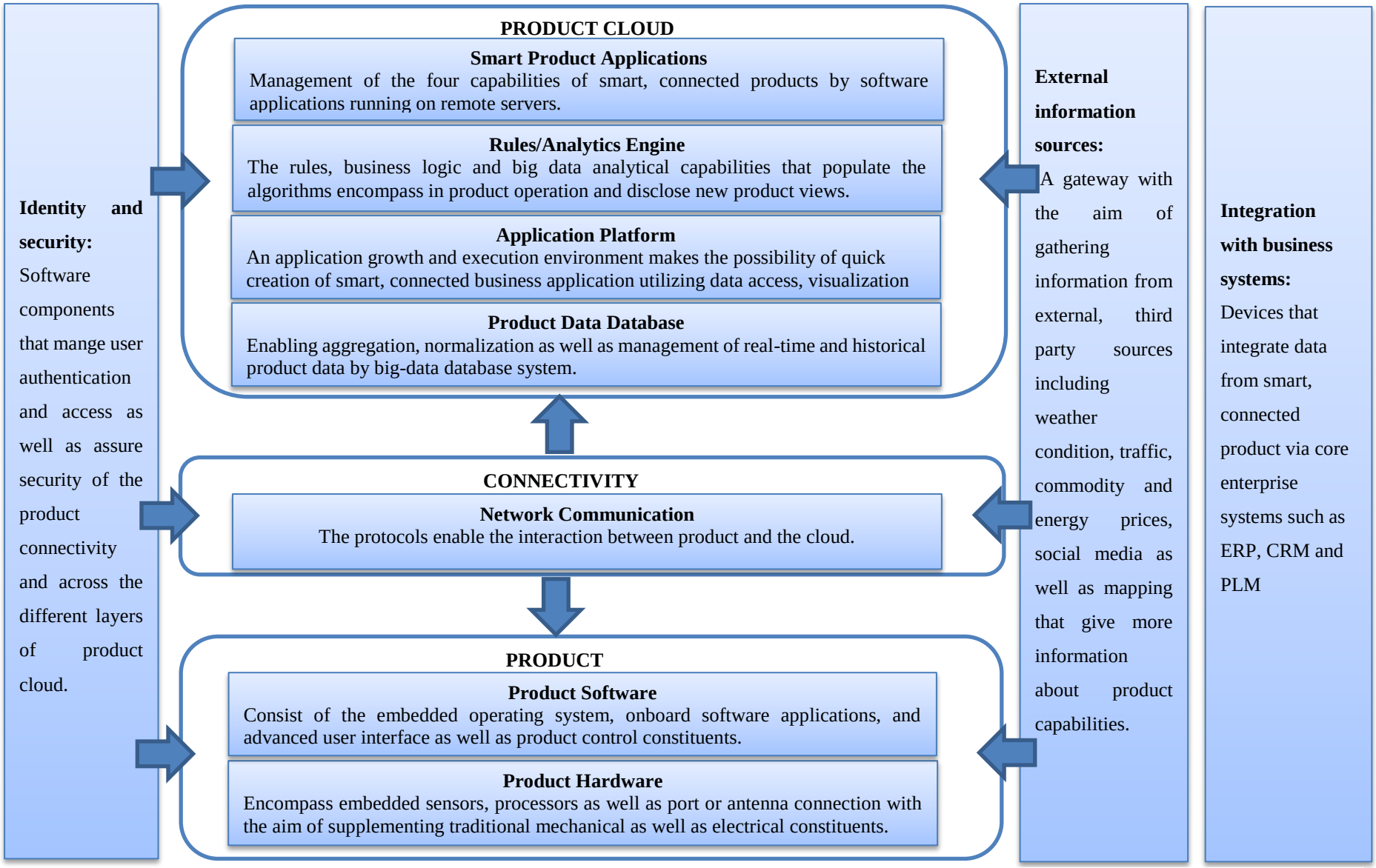

Figure 11: New technology stack for smart, connected products (Porter & Heppelmann, 2014)

IOT can assist CE to provide a way of dealing with some of the critical issues related to qualification, classification, as well as categorization among buyer-supplier relationship in the CE. These issues are in a way of achieving CE ideas, in setting where products circulate beyond the direct governance of one coordinating firm. For instance, with the help of IOT, companies can investigate opportunities for resource usage capacity in logistic domain which are related to the time when forward and reverse logistics loop are overlapped. Having good knowledge about the status of the products and their elements provides opportunities for the companies to adjust by themselves or with the help of selected partners or network paths in order to tackle with various recovery alternatives such as refurbish, dismantle, as well as dispose. Furthermore, apart from selling and renting equipment, firms might provide a vast numbers of service opportunities such as maintenance, disposal, as well as replacement of equipment. “Smart, connected products” which created with the technology of IOT, has the ability to both enhance the development of CE and market approaches (Spring & Araujo, 2016).

IOT has the ability to make the possibility of constant tracking of products whether these products attached or detached from the networks of other products and actors. This level of ability enables more than remote monitoring of the main items of equipment such as creating smartness for cheap products, data gathering, data analyzing, capacity development, as well as understanding of multiple products interaction in detail. Moreover, IOT plays an important role in making the possibility of qualification and institutional structures as well as procedures that are needed to actualize the CE (Spring & Araujo, 2016).

The concept of IOT and wireless technology will promote the efficiency and successfulness of the various central city and national environmental programs. Observation of the vehicle toxic emissions with the aim of controlling the air quality, collecting used materials, the reuse of packaging resource, and electronic pieces, as well as disposal of electronic waste, can be named as the examples of the IOT in recycling industry which is one of the principles of CE (Bandyopadhyay & Sen, 2011).

As it can be seen in *Figure 12*, the smart CE starts with tracking products throughout their use cycle and then it continues with optimizing fleet efficiency. In this step, IOT will provide information about the most efficient transportation modes from trucks and trains to ship and planes. The next step is to optimize delivery routes. In this stage, IOT provides real-time

data which illustrates goods and transport locations and leads to quick routing, reduce fuel consumption, as well as decrease damage, and loss of asset. The fourth step is to track products throughout their use cycle especially after sale. Avoiding waste is the next step in CE, in this step the data which provided with IOT technology gives more information about waste operations in a way that enhance the system and design out waste. The sixth section is about sorting recycled materials. This phase encompasses exact sorting of different kinds of materials in order to be prepared for reuse and recycling. The last action is to give permission to the owner to calculate the costs, value, as well as benefits of entire logistics alternatives. Therefore, the owners can monitor and control the process with smart devices remotely (MacArthur & Waughray, 2016).

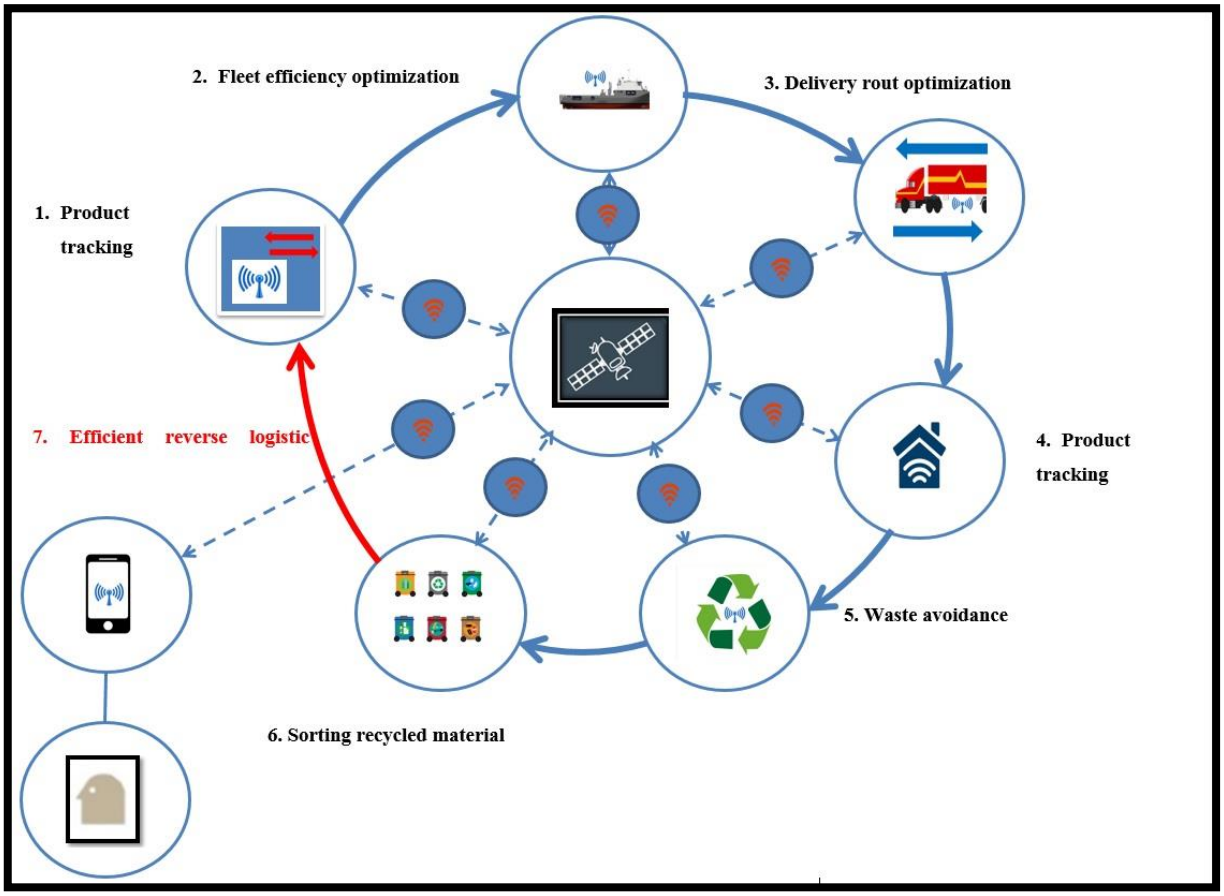

Figure 12: Intelligent CE (MacArthur & Waughray, 2016)

Rapid growth in the number of businesses leads to harness the value which created by the synergies between CE and IOT technology. The application of these two concepts can be presented in different sectors such as manufacturing, built environment and infrastructure, energy and utilities, agriculture and fishing, logistic and waste management, as well as smart cities which encompass both incumbents as well as disruptive innovators. Moreover, the combination of these two technologies has the ability not only to create direct value for end users, to make extreme shift in resource productivity of societies. This shift can be achieved by establishment of new ecosystem for presenting service in a way that eradicates negative externalities or requirement for the combination of some resources. Furthermore, integration of CE and IOT creates great opportunities for both innovation and value creation. Extension of useful lifecycle, increase in asset's consumption, minimizing the production of new products from virgin materials, less waste creation, and looping assets, as well as recreation of natural capital, can be named as the value which provided by CE. In addition to this, gathering information about the location, status, and availability of assets can be described as the value which provided by IOT technology. Therefore, a combination of these two concepts leads to a wide range of opportunities which make a drastic shift in the nature of products as well as business models (MacArthur & Waughray, 2016).

In conclusion, according to different academic research, IOT technology can be named as the central enabler for CE business models (MacArthur, 2012). IOT provides various opportunities for innovation in CE principles. Therefore, combined lenses of CE and IOT technology leads to value creation in a different domain such as optimization of capacity utilization, implementation of predictive maintenance, as well as automatic sale and inventory management, while decrease human intervention in 3R principles of CE (MacArthur & Waughray, 2016).

6 PRACTICAL PERSPECTIVE

This section classifies into two parts. The first part is about SITRA which gives more information about this Finnish Innovation Fund organization, its background and some of the projects that have been involved in its activities. The second part is the information which has been gathered from the semi-structural interview with Kari Herlevi, who is the senior lead in the CE area at SITRA. There are many reasons for selecting this organization. The first one is its focus on sustainable well-being. The second one is that CE is one of the four concentration area of SITRA under the carbon neutral and resource-wise society. The last reason is its focus on bringing current knowledge together in order to have a sustainable society. All these mentioned reasons help to give a comprehensive perspective of this research and compare the information in literature and real world.

6.1 SITRA

SITRA is a public fund which has established as an organization of the bank of Finland which provided an endowment of 17 million euros as capital cost in 1967 in order to regard the 50th years of Finland's independence. According to the last report provided in April 2016, the market value reached at 771 million euros at the end of 2015 (SITRA, 2016).

Employees of SITRA are forward planning and thinking as well as anticipating social transformation with the main focus on its impact on human's life. Furthermore, the group activities of SITRA lead to improving novel operating model and suppress business with the aim of sustainable well-being in order to construct a successful Finland in future. The activities of SITRA are conducted based on the perspective of Finland as a leader in sustainable well-being. They believe that well-being is sustainable if it is shared by people, the environment, and the economy. The SITRA's strategy encompasses improving new ideas of what the good life is, discovering operational models which create a novel type of society as well as promoting business operations (SITRA, 2016)

SITRA not only recognizes the need for social shift and make the possibility of these shifts but also project, analyze as well as evaluate the forces of social shifts and their effects on Finland. SITRA can be named as an independent operator which has a golden opportunity to perform rapidly to the major problems which are related to Finnish people and accelerate

shifts that enhance well-being. Practical experiment, compiling cross-boundary networks as well as grow and finance business operations are among the activities that SITRA is doing (SITRA, 2016)

The activities at SITRA can be divided into four parts. The first SITRA's activity is to recognize as well as connect the partners who required discovering a solution for different issues. Next is that SITRA acts as a facilitator as well as the responsible party in projects. Starting experimental projects as the owner is another activity and the last one is to invest capital in the key companies of the business ecosystem (SITRA, 2016).

Intelligent electronics power is one of the investment projects at SITRA which related to digitalization. SITRA with Syncron Tech Oy has invested in sustainable Energy Asset Management (SEAM) with the aim of smart consumption of electric power. SEAM provides solutions for large-scale consumers of electricity including industrial and corporate clients in order to decrease consumption at peak hours, while increase usage at the time that the prices are low. The services that provide by SEAM are fully automated and its real-time service concept is unique not only on a national scale but also attract others outside Finland. This type of management based on demand leads to a reduction in customer's electricity as well as cuts the industrial carbon footprint (SITRA, 2014).

On the other side, SITRA has been conducted research that the CE provides an opportunity for Finland with the value of 1.5 to 2.5 billion euros. The fundamental factors including high education level, solid technological expertise, as well as a strong reputation as a clean technology operator, have been placed Finland in a strong position to thrive in the face of global competition. Therefore, SITRA tries to increase the large amount of waste that could be reused as raw materials, as well as energy source. Finland has conducted many activities such as energy efficiency in paper industry, bottle recycling and flea markets towards CE practices. SITRA contributes to CE in Finland with three different ways. The first one is developing the roadmap in collaboration with other actors. The second one is to plan and invent business models for companies with an application in CE. The last one is to carry out experiment with operational models within administration in order to create motivation for shift to CE (SITRA, 2016).

6.2 SITRA's Perspective

The information which describes in this part has been achieved from the face to face interview with Kari Herlevi at SITRA. The duration of the interview was about one hour and the interview was audio recorded with the previous consent of the interviewee and extensive notes were taken during the interview. The Interview was based on semi-structured question and has been categorized in three themes which can be seen in *Appendix 1*. The first theme is about the "Sustainable" overview while the second one is about "Innovation for sustainability" perspective and the last one is the overview of "Internet of things in Disruptive innovation for sustainability".

Bio-economy, clean tech, as well as CE, are the terms that used in Finland in order to have a sustainable business. CE is not the last goal but just a toolkit which concentrates on decoupling economic growth from the use of natural resource and climate emissions. Sustainability, bio-economy, and clean-tech can be described as the part of CE which combination of all these concepts leads to sustainable business. Furthermore, Sustainability is the most important part of CE while there are many different factors in bio-economy more than biological things that the combination of them results in sustainability. Moreover, clean technology is related to the technologies that utilize in order to create economic in a circular shape. Sustainability can reach from the social, environmental and economic perspective altogether. Consequently, sustainable nations have to have enough well-done educated people and jobs, then they should have a clean environment and finally, they have to have developing economic.

The business model can be named as the most significant practices for success in CE. The most important business cases are from Finland and Finland has the golden position in terms of sustainability. Different business cases based on CE practices have been proposed in a very innovative way. These business cases are mainly based on the method of creating changes in core business and getting more circular thinking which are very important findings rather than the techniques for saving resource in a value chain of the company or in the company large value chain. Therefore, the main focus of these people is not limited to the recycling methods but they try to eliminate waste or use it as the products in other places.

From the CE point of view, In Finland, bigger Finnish companies understand the mega trends of climate change and diminish resources in the certain aspects while small-medium size

companies have the lack of resources and time to investigate the global trend of CE. There are many different challenges in terms of CE, but the most important one is lack of awareness. Therefore, companies need to be aware of successful business cases that are conducted in circular fashion. In this way, companies could learn from each other by implementing something that is conducted in somewhere else in EU companies. Funding and support for innovation, R & D and good networks as well as competencies are among the other challenges for CE. Achievement of fast growth needs to broaden perspective domain outside of Finland. This will leads to face with similar chance in compare to other companies and circular thinking could provide more competitive edge better than other.

Different factors existed that influence the companies to refuse to implement CE in their business. Lack of data and understanding of alternative ways of doing things can be named as the factors which lead to unwillingness to try CE. Moreover, many companies still afraid of losing their business and continue their business in a linear way. On the other hand, changing business model needs shifts in some other items including different methods for taking the product back and leasing model. Besides, some kind of system for tracking products or may be some kind of fee for returning or calling back product are among the factors that result in reluctant for companies to change from a linear economy to CE.

Innovation should include sustainability factors and sustainability will not happen without different innovative methods to tackle climate change, resource scarcity as well as other environmental, social and economic issues. In many statistics, Finland is ranked one or two in innovation but the problem is that many of these innovative solutions are considered in general way rathen than being based on specific details. The fact is that companies need to sell their products as well as services and growing their business. Therefore, they put most of their concentration on these issues.

“Neste” can be named as the relevant example in this regard which has success story of sustainable products. “Neste” rebuilds diesel beside the kind of old fashion with the vast number of investments in R & D. This Finnish company can grow in 10 years with significant business in renewable diesel or bio-diesel that is sustainable and bio-based residuals. Apart from the case of “Neste” which can be named as disruptive innovation, Tesla is another example in electronic vehicle market which is disruptive innovation. The visionary personal with excellent understanding, supporting super teams for delivering and finally investors for supporting and backing them up are among the enabling factors that these

companies have in their business. In practice, the current situation is that the number of companies with disruptive innovation is rare. Achievement of disruptive innovation is very hard for individual companies which try to maintain their business positions to do something very risky and innovative. Resources, competencies and kind of broad attitude are required to have disruptive change in system. In terms of sustainability, disruptive innovation in future could be something including elimination of fossil fuel cars, clean air, less noise, less traffic, fewer cars own by citizen as well as smart system.

The main point of digitalization in service is that there is no need to concentrate on selling products and that is the main thing in CE for value creation. With the technology of IOT, customers can be served more wisely as well as product can be tracked in order to be aware of the condition, place and status of the products. Furthermore, maintaining the value of the product for long period of time, remanufacturing and leasing product again is not possible without digital means including sensors, tracking devices and RFID tags. “Lease Green” can be named as the company that decrease the use of energy and saves a lot of money by smart buildings or smart solution. Therefore, IOT and digital solutions have not reach the entire business potential yet and need to find new things to do with the network they have.

IOT can provide more value for each dimension of sustainability. In the economic dimension, gathering more information about products, leasing product again and replacing technology in all parts are among the activities which lead to economic growth with digital solutions. In the environmental dimension of sustainability, less traveling via remote working results in a decrease in CO2 emission. In addition to this, smart use of materials and virgin resources leads to decrease pollution and environmental issues. From the social point of view in sustainability, higher value added jobs and educated people leads to less social problems in nations.

Smart products are those products using digital solutions and embedded with smart tags. This type of products has circular thinking, made of renewable sources and utilizing renewable energy as well as replace virgin materials, while they are smart in sense of making a solution for customers’ issues in a new way. Therefore, currently, many companies do not act in a smart way because they always try to sell what they think is nice and useful and meet the needs of the end customer with selling instead of leasing or using the service.

As conclusion, there is a need to rethink about the concept of sustainability and try to find out what are the kind of important disruptive innovation that are coming and how sustainable they are and try to think about a typical example where there is the combination of sustainable and business. And then maybe try to somehow challenge companies to follow these examples and hopefully doing business in a sustainable way.

7 DISCUSSION

This chapter divides into two parts. The first one is the results which compare the acquired findings from the literature review with SITRA's perspective. The second part is further research which studies possible future research, limitations of the study and implications.

7.1 Combining Insights from Literature Review and SITRA's Perspectives

The main aim of this part is to make a comparison between the findings which achieved from the literature review and the one which gathered from SITRA's perspective.

As discussed before, there are many different challenges in order to access to disruptive innovation for sustainability. These challenges divide into two groups which some of them enables disruptive innovation for sustainability and some of them can be named as the barriers to be successful in this regard. *Table 4* shows the information which has been acquired from the literature review. As it can be seen in *Table 4*, enabling factors and barriers can be studies based on two different groups. In the first group, four enablers in disruptive innovation for sustainability have been defined while two different challenges have been described in this regard. In the second group, enabling factors have divided into external and internal factors while the barriers have been classified in there different levels (Szekely & Strebel, 2013).

From the viewpoint of SITRA, people with a good knowledge, visionary, and understanding, supporting super teams and investors are among the enabling factors in disruptive innovation for sustainability, while frightening from losing the current business and have resistance among innovation and risky activities can be named as the challenges in disruptive innovation for sustainability among companies. Moreover, changing the core of the business model that shifts the way of thinking from linear to circular can be named as another enabling activity in disruptive innovation for sustainability from SITRA's perspective, while lack of awareness, knowledge, and data, lack of good networks are among the other challenges which companies face with in order to be successful in disruptive innovation for sustainability.

Table 4: Enablers and barriers in disruptive innovation for sustainability

Enablers		**Barriers**		
• Closing the loop • Transforming supply chain • Leapfrogging the unsustainable • Partnership		• Balance creation between three dimensions of sustainability • Employee resistance		
Internal factors	**External factors**	**Firm-level**	**Local, national, international levels**	**All levels**
• Competition • Knowledge • Culture • Firm's capabilities	• Physical and biological shifts to natural environments • Evolution in understanding of the shifts • Government policies • Social forces • Customer demands • Needs for reduction of natural resources.	• Lack of knowledge and skills • Frightening for creation of trade-offs between quality and sustainability performance • Well-established pathway dependencies • Delicate customer demands	• Delicate voluntary agreement • Creation of perverse motivations by public policy	• Lock-in to wasteful • High reliance on fossil fuels • Linear system at all levels.

According to investigation on different research articles, RFID tags and embedded sensors in IOT technology make the possibility to track the objects in every time, location and status which leads to sustainability (Atzori et al., 2010). Moreover, IOT technology provides smartness for objects which results in saving and efficiency increase. IOT provides the vast number of value in each dimension of sustainability. In social dimension of sustainability, with the technology of IOT, smartness in different domain not only improves the quality of life, but also enhances the efficiency of the city services. Moreover, smartness improves safety and security of societies in different domain such as pharmaceutical industry as well as aviation industry. Therefore, people could benefit from social sustainability with the technology of IOT. In the economic dimension of sustainability, IOT via the provision of precise and real-time information will provide more value and economic growth in different industry such as manufacturing, agriculture, transportation, retail, logistics and supply chain management as well as insurance. In the environmental dimension of sustainability, IOT via sensor technology and monitoring system enable environmental safety, quick detection of disaster as well as resource efficiency and pollution prevention. *Table 5* shows the value which IOT will create in three dimension of sustainability.

According to SITRA's perspective, in the social dimension of sustainability, higher value added jobs and educated people leads to less social problems in nations, while gathering more information about products, leasing product again and replacing technology in all parts are among the activities which lead to economic growth with digital solutions in the economic dimension of sustainability. In the environmental dimension of sustainability, less traveling via remote working will lead to a decrease in CO2 emission. Moreover, smart use of materials and virgin resources leads to decrease pollution and environmental problems.

Table 5: Value creation in three dimensions of sustainability

Value creation in Social dimension	Value creation in Economic dimension	Value creation in Environmental dimension

• Personal life
  ○ Smart clothes
  ○ Smartbooks
  ○ Smart washing system
  ○ Intelligent traffic service
  ○ Smart parking service
  ○ Smart crosswalk service
  ○ Smart education
• Medical and healthcare
  ○ Smart treatment
  ○ Quick detection
• Purchasing
  ○ Smart checkout
• Aerospace and aviation
  ○ Electronic data transfer
	• Industrial IOT
	  ○ Intelligent products
	  ○ Novel service and operating models
	  ○ Novel production methods
	• Manufacturing industry
	  ○ Monitoring status of shop floor and goods
	  ○ Monitoring condition of production machines
	• Agriculture industry
	  ○ Monitoring quality of soil
	  ○ Monitoring atmosphere condition
	  ○ Monitor a quality of agricultural products
		• Environmental monitoring
		  ○ Danger detection
		  ○ Disaster protection
		  ○ Early alarm
		  ○ Pollution protection
		  ○ Fast control
		  ○ Optimum energy control
		• Logistics
		  ○ Automatic warehouse
		  ○ Better asset management
		  ○ Proactive planning
		• Smart building
		  ○ Reduce energy usage
		  ○ Promote comfort
		  ○ Heating adjust
		  ○ Lighting adjust
		  ○ Energy saving
		• Automotive industry
		  ○ Monitoring status of the vehicle
		  ○ Improve quality control
		  ○ Improve customer service
		  ○ Intelligent car

As discussed by previous research, IOT is one of the main enablers for CE business models to create improvement in CE at companies (MacArthur, 2012). The arrival of IOT in CE makes disruptive changes in many different fields of industry. Smart, connected products improve the performance of CE and market approaches with different capabilities including monitoring, control, optimization as well as autonomy (Porter & Heppelmann, 2014). The abilities which created IOT to track the products remotely enhance the performance of the system for intelligent cheap products, better quality management, optimization in recycling as well as gathering, analyzing and availability of data (Thomas & Trentesaux, 2014; Spring & Araujo, 2016). Better access to the history of the system in case of recovery activities such as refurbish, dismantle, and dispose, can be named as another enhancement which provided by the utilization of IOT in CE (Thomas & Trentesaux, 2014).

According to SITRA's perspective, the most important enhancement in CE which digitalization made is related to the change concentration of the companies from providing service instead of selling products. SITRA believes that with the technology of IOT, customers can be served more wisely as well as the product can be tracked in order to be aware of the condition, place, and status of the products. Furthermore, maintaining the value of the product for long period of time, remanufacturing and leasing product again is not possible without digital means including sensors, tracking devices and RFID tags.

As a result, in order to answer the main research question, seeking for the answer of the three above sub-questions was necessary. Therefore, IOT can facilitate the occurrence of disruptive innovations for sustainability in many different industry domains. IOT provides more value in each dimension of the sustainability. According to the information that conducted in this research, IOT opens a new room for revolution by embedding RFID tags, sensors, and actuators in objects which result in healthier life, safer cars, smart home and workplace as well as an environmentally friendly place to live.

7.2 Further Research

The need for further research is required according to the novel nature of this research. Making a standard framework for the IOT in order to recognize the level of digitalization in each field and industry or even companies can be named as an important research for the future. It is noteworthy to define a standard framework for digitalization in companies or businesses. Therefore, specialist of this knowledge should concentrate on designing the framework for digitalization. In this way, companies can find their level of digitalization and try to make progress for digitalization, which can be named as one of the influential factors for disruptive innovation and sustainability.

On the one hand, the main concern using IOT is creating possibilities to connect with devices, providing smartness for these devices and using this technology in a way that is more secure, reliable, and safe enough for the users. It has done more practices to improve security, safety, and reliability in this technology, but still it needs to enhance it in a way that users feel secure and rely on IOT technology.

On the other hand, the key challenges in occurrence of disruptive innovation for sustainability is employee's resistant in the early stages of thinking. In my view, Managers should educate employees about the application of the novel technology and its positive effects on businesses, companies or individuals. Therefore, creating long term plan, providing guidelines and motivations for employees to promote disruptive innovation for sustainability, can be named as the attempts to overcome with this issue.

Moreover, as the CE has three main principles, under the title of 3R principles, concentrating on each principle in order to enhance the CE performance with the help of IOT technology can be named as the useful research for the future. There is a lack of studies in the effects of IOT technology in each principles of CE inclusively.

From my point of view, there is a need for more multi-disciplinary research on relationship between IOT, sustainability, disruptive innovation, and CE. In this way, people with different jobs or from different areas of study can involve to derive benefits from these concepts. Multi-disciplinary research on these topics, provides many opportunities to come up with many different solutions for issues in large scale.

8 CONCLUSION

The ultimate goal of this study is to find connections between IOT and disruptive innovation for sustainability and find the answer to the question of *how can IOT facilitate the occurrence of disruptive innovation for sustainability?* In order to achieve the final goal, three different questions have been defined to answer.

In answer to the question of *what are the challenges of disruptive innovation for sustainability,* Different enabling and barriers define in disruptive innovation for sustainability. In general, closing the loop, transforming supply chain, leapfrogging the unsustainable activities, partnership, and supporting team are among the enablers of disruptive innovation for sustainability. In detail, enablers divide into internal and external factors. Competition, knowledge, culture, and firm's capabilities are identified as the internal factors, while physical and biological shifts to natural environments, evolution in understanding of the shifts, government policies, customer demands, and needs for reduction of natural resources are mentioned as external factors in disruptive innovation for sustainability. On the other hand, barriers are creating balance between three dimensions of sustainability, resistance of employees, and frightening from losing the current business in general. In detail, barriers classify into three levels: in firms level, lack of knowledge and skills, frighten for creation of trade-offs between quality and sustainability performance, well-established pathway dependencies, and delicate customer demands are barriers of disruptive innovation for sustainability. Delicate voluntary agreement, and creation of perverse motivations by public policy are berries in local, national, and international level. Finally lock-in wasteful, high reliance on fossil fuels and linear system are the barriers at all levels.

In order to answer the research question of *how can Internet of Things provide value for each dimension of sustainability?* The impact of IOT in social, economic, and environmental dimension of sustainability is studied. The effect of IOT in social dimension of sustainability improves the quality of life and provides comfortable life for individuals. For example, with the technology of IOT, smart clothes, books, washing system, education, and intelligent traffic service improves the standard of living, security, and safety in personal life. Smart treatment and quick detection provide value in medical and healthcare domain. IOT provides electronic data transfer in aerospace and aviation industry which promotes safety and

security for passengers. All of the mentioned values result in high value added jobs, educated people, as well as less social issues in nations. In economic dimension of sustainability, IOT provides economic growth and competitive advantages in many different industries. For instance, intelligent products, novel services, and operating models, as well as new production methods are among the values which create in industrial IOT. Remote monitoring is an important action which offers a possibility of checking the status of the product and production line, location of the products and delivery time. In environmental dimension of sustainability, IOT opens up a possibility to reduce natural resources and save energy in different places. Optimum energy control, recognition of disaster at early stages, danger detection, and pollution protection are among the values which achieve by environmental monitoring in IOT technology. Automatic warehouse, better asset management, and proactive planning in transportation and logistics result in using less fuels and reduce air pollution.

The third guiding question was *how can Interne of Things enhance the performance of Circular Economy for disruptive changes?* In general, IOT provides a possibility of smart, connected products which make disruptive changes in business models. Monitoring, control, optimization, and autonomy are among the main capabilities of the smart, connected products. Product tracking and utilizing IOT technology in 3R principles of CE promote the performance of CE with better quality management, optimization in recycling, gathering, analyzing, and availability of data.

It is concluded that IOT offers the possibility to a revolution in personal and working life. The solutions provided by IOT open up a possibility to economic, industrial, and business development. These solutions improve not only the social sustainability but also environmental sustainability and enable the provision of peoples' facilities to have a safe, secure, and environmental-friendly life.

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APPENDICES

Appendix 1: Interview Questions for Semi-Structured Interview

1 Overview of Sustainability

1.1 In your view, what is the current status of Finnish companies in terms of sustainability?

1.2 What are the challenges for sustainability in Finnish companies? (Social challenges, technological challenges)

1.3 What do you see is the role of CE in sustainable development?

1.4 What are the organizational practices for the success of CE?

1.5 What are the challenges of CE in Finnish companies? How do the companies tackle these challenges?

1.6 What internal and external factors are influencing companies' CE actions?

2 Overview of Innovation for sustainability

2.1 What is your opinion about the current status of Finnish companies in terms of "Innovation for sustainability"?

2.2 In your opinion, what is required to achieve disruptive innovations for sustainability?

2.3 What are the major challenges to adopting disruptive innovation for sustainability in Finnish Companies? How could these challenges be overcome?

2.4 What are the enabling factors for adopting disruptive innovation for sustainability at Finnish companies?

2.5 What are the critical organizational practices for the success of the disruptive innovation for sustainability?

2.6 What are the impacts of disruptive innovation for sustainability at the company level? Network –level? Societal impacts?

3 Overview of IOT in Disruptive innovation for sustainability

3.1 How do the Finnish companies create value for sustainability via the concept of IOT?

3.2 How IOT or smart products can facilitate CE at Finnish companies?

3.3 How IOT provides value in each dimension of sustainability (Social, environmental, economic) at the Finnish companies?

3.4 How do the smart products provide value for the sustainable innovation in Finnish companies?

3.5 How can IOT facilitate the occurrence of disruptive innovation for sustainability in Finnish companies? Are there any special requirements?

3.6 Is there anything that you want to add?