The Sustainability of University-Business Innovation Clusters: The Case of IoT Rapid-Proto Labs

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The objective of this study is to identify sources of support for the IoT Rapid-Proto Labs to enable the success and sustainability of the project. This study is done for the European transnational multidisciplinary project IoT Rapid-Proto Labs, which seeks to accelerate Internet of Things (IoT) product development by bringing together higher education institutions and businesses and to develop students the multidisciplinary skills most companies feel they currently lack. The IoT Rapid-Proto Labs is coordinated by Haaga-Helia University of Applied Sciences and funded by European Union Erasmus+ Knowledge Alliance Programme until the end of 2020.

The main research problem in form of a question is: What are the sources of support within the IoT industry available for the IoT Rapid-Proto Labs project after EU project funding ends in 2020?

The theoretical framework of this study is based on University-Business Innovation Clusters, which is supported by the paradigm of Open Innovation. Different actors of University-Business innovation clusters and the relationships between them are studied, as well as the factors and impediments to success and sustainability and the different funding and financing options and models. The IoT market space is also studied to identify the different stakeholders who are active in the development of the industry, and to explain the sources of funding and support which are available for developing and commercializing the sector.

The study was executed with action research and data was gathered using qualitative research method including literature review and seven semi-structured expert interviews.

The findings indicate that IoT Rapid-Proto Labs already possesses many of the requirements University-Business innovation clusters need to be successful and sustainable. It offers the students, industry, and market relevant knowledge and solutions thus contributing to the competitiveness of the European market. The project could seek new industrial and business partners to strengthen the collaboration, broaden the solutions portfolio and the geographical area of operation. The findings suggest that a change in the funding model is needed, as multiple financing sources would support the sustainability of the innovation cluster.

In conclusion, this research reached the set objectives and offers insights on the IoT market and the importance of University-Business collaboration and the factors contributing to its success and sustainability.

Keywords
Internet of Things, IoT, University-Business Innovation Clusters, Case Study

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1 Introduction

The Internet of Things (IoT) represents the next step towards the digitization of our society and economy. IoT is experiencing an explosive growth and will impact almost every industry. The utilization of multiple sources of knowledge is increasingly required as is talent with relevant and real-life multidisciplinary competences. This study is done for a European transnational multidisciplinary project IoT Rapid-Proto Labs, which is coordinated by Haaga-Helia University of Applied Sciences and funded by European Union Erasmus+ Knowledge Alliance Programme. The project seeks to accelerate IoT product development by bringing together higher education institutions and businesses and to develop students the multidisciplinary skills most companies feel they currently lack. This study aims to seek sources of support for the IoT Rapid-Proto Labs project after EU project funding ends in 2020 to help secure the long-term success of the project.

1.1 Sponsor Project Background

IoT Rapid-Proto Labs is a European transnational project, that is coordinated by Haaga-Helia University of Applied Sciences, other partners include University of Leiden (The Netherlands), University of Trento (Italy), Technical University Delft (The Netherlands), Bruno Kessler Foundation (Italy), 247GRAD (Germany) and Houston Inc. Consulting (Finland).

The IoT Rapid-Proto Labs project aims to accelerate the IoT product development, strengthen university-business collaboration and support the creation of collaborative educational ecosystems. The collaboration will add value for enterprises, and strengthen the multi-disciplinary skills, employability, and career prospects of students enrolled within the project. The multidisciplinary course curriculum (ICT, Design and Electrical Engineering) is targeted on real problem-based activities. Cross-border teams of scholars, teachers, and partners will jointly and rapidly set-up, trial and test innovative and challenging IoT products and applications for SME and Start-up clients. Student teams are continually supported within the discovery, design, development and test process by teachers, external coaches and client staff. Distributed teams of scholars from the three countries are supported by a Project Arena (web-platform) which enables them to effectively collaborate on rapid-prototyping of products and solutions. The Project Arena also stimulates the flow of information and innovation between universities, companies and other stakeholders. The fields of study embedded within the project curriculum (e-Competences, design thinking, agile processes) are highly relevant for today’s market. By creating more efficient links between education, research and enterprise innovation, the IoT Proto-Labs project contributes to the modernization of Europe's Higher Education system and reinforces the European Knowledge Triangle. Learning design relies upon developments in theories of effective learning and teaching with realistic and sophisticated task situations, mutual interaction and cooperation in an authentic work environment. The IoT Rapid-Proto Labs project is presented in Figure 1. (IoT Rapid-Proto Labs Project Proposal 2017.)

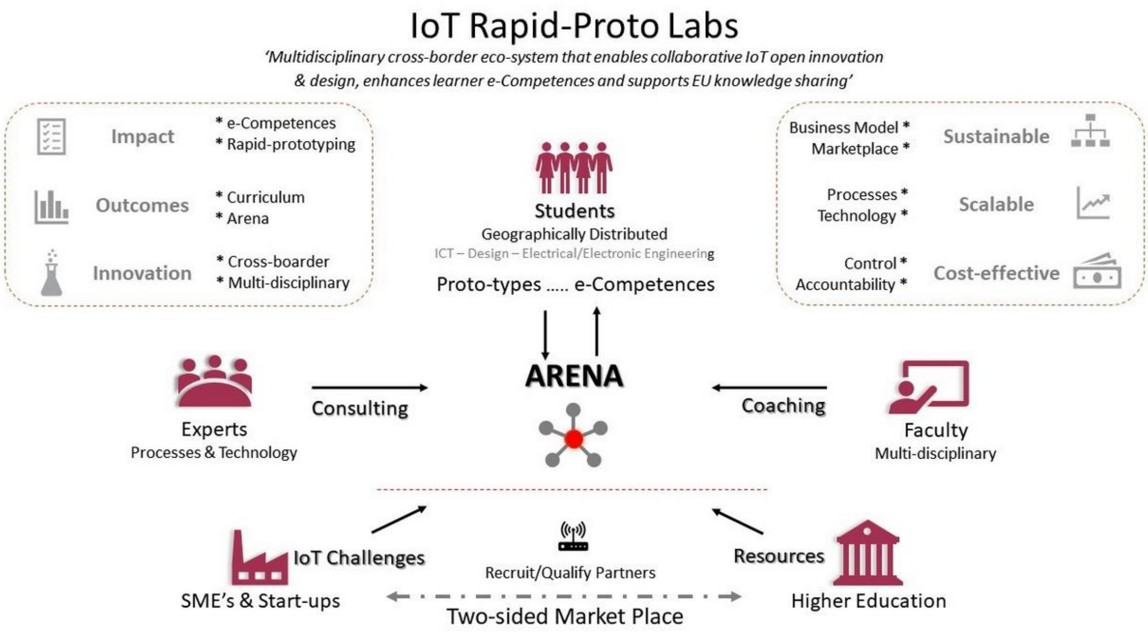

Figure 1. IoT Rapid-Proto Labs (IoT Rapid-Proto Labs Project Proposal 2017)

1.2 Needs and Objectives

The study is motivated by the fact that the IoT is experiencing an explosive growth and will impact almost every industry. The implications of IoT solutions for European SME's and Start-ups are particularly important, as 90% of them feel that they are already lagging in digital innovation. The risks and low success rates (typically between 15% to 25%) associated with new product development are deterring EU companies from investing in IoT research and development. European SME's and Start-ups must start taking proactive steps to address the changes brought by IoT or risk getting left behind and putting their businesses at a competitive disadvantage. Small and medium size enterprises represent 99% of all businesses and 85% of new jobs in the EU. Only 14% of European SME's have adopted to IoT and 90% of companies say that they do not have the right people in the right roles to make the most of the IoT opportunity. IoT Rapid-Proto Labs serves as a low-risk integrative enabler of SME and Start-up IoT innovation. The project enables the modernization of learning opportunities, skills development, access to information and recognition of learning outcomes. (IoT Rapid-Proto Labs Project Proposal 2017.)

According to the European Commission (2016), the development of IoT offers Europe an incomparable opportunity. Europe’s future digital industrial strengths are dependent on the capability of its industry to capture the opportunities coming from the wider dispersion of digital innovation across sectors. The formation and reinforcement of new digital value chains will draw investments and innovators to Europe. The digitalization of all industrial sectors is crucial to ensure a strong European industrial base and manage altering value chains and business models.

The purpose of this study is to research the actors of University-Business innovation clusters and the relationships between them, define the factors and impediments of success and sustainability of innovation clusters and to research the different funding and financing options and models for them. The aim of this study is to identify sources of support for the IoT Rapid-Proto Labs project after EU project funding ends in 2020. This study aims to explore the European IoT market, describe the different stakeholders (public and private) who are active in the development of the industry, and to explain the sources of funding and support which are available for developing and commercializing the sector.

The value of the study for the IoT Rapid-Proto Labs project is made by identifying available sources of financial support to sustain the project after EU funding has ended. This is essential for the long-term success of the IoT Rapid-Proto Labs project. My role as the researcher in this aim is to identify, describe and explain these potential sources of support. The long-term success of the project will assist European SME’s and Start-ups to adopt to IoT, thus contributing to European economic growth, the modernization of Europe’s Higher Education system and reinforcing the European Knowledge Triangle by creating more effective links between education, research and enterprise innovation.

1.3 Innovation clusters

This study aims to research the actors of University-Business innovation clusters and the relationships between them, define the factors and facilitators of success and sustainability of innovation clusters and to research the different funding options and models. The theory for innovation cluster actors and their relationships is based on Porter (2000), Sölvell (2008), Engel (2015), Simmie (2004), Gawarzynska (2010), Mazur et al. (2016), Wagner et al. (2012) and Lindqvist & Sölvell (2011).

Porter (2000, 15) has defined clusters as geographical concentrations of interconnected companies, government, finance, academic institutions and institutes of collaboration (e.g. standards agencies, trade associations) within a sector that compete but also collaborate.

Clusters exist virtually in every national, regional, state and metropolitan economy, particularly within the more advanced nations. Innovation clusters have similarities with the traditional definitions of business clusters, but also differences. The traditional definition does not explain how highly innovative clusters are able to support the continual emergence of high-growth companies, a number of which diverge from the initial business concentration. (Engel 2015.) Recent studies have shown that innovative companies use national and international linkages more than local networks, operate usually at national and international levels more than locally and that they have comparatively high rates of export. (Simmie 2004.)

Globalization influences how companies operate, compete and innovate domestically and internationally. Global competition shortens product life cycles, while innovation is riskier and costlier since it requires integration of various technologies. The necessity for interdisciplinary cross-border and cross-sector research makes it harder for a single company to successfully innovate own their own. Still innovation is crucial to succeeding within the competitive contest for market share and a pre-requisite for sustainable development. The employment of multiple sources of knowledge is increasingly required. Companies are collaborating with external partners adopting an ecosystems of innovation. These innovation networks are referred to as innovation clusters. (OECD 2008, 9-27.) Innovation clusters are groupings of independent undertakings designed to stimulate innovative activity, they include Start-ups, SMEs and large enterprises as well as higher education institutions, research centres and public organizations operating around innovative products or services. (Wagner et al. 2012) Innovation clusters have a greater ability of innovation because they are supported by a system of close relationships between all cluster members. (Mazur, Barmuta, Demin, Tikhomirov & Bykovskiy 2016).

Sölvell (2008) has defined a model based on the actors whose decisions and actions influence cluster development. The six actors of the model are industry, financial actors, public actors, academic actors, organizations for collaboration and media, as presented in Figure 2. The industry is composed by upstream and downstream companies involving both large companies and SMEs, private industry including competitors, suppliers, buyers and companies in related technologies that share common factors such as skills or technologies. Financial institutions include traditional banks, commercial banks, venture capital, private equity and angel networks. Public bodies include national ministries and agencies involved in industry and economic development policy, regional policy, technology policy, as well as local communities. Academic factors include universities, research institutes, technology transfer offices and science parks. Organizations for collaboration are often both private and public-private such as chambers of commerce, formal networks and cluster organizations. Media creates news and stories around the cluster and help to build a national brand.

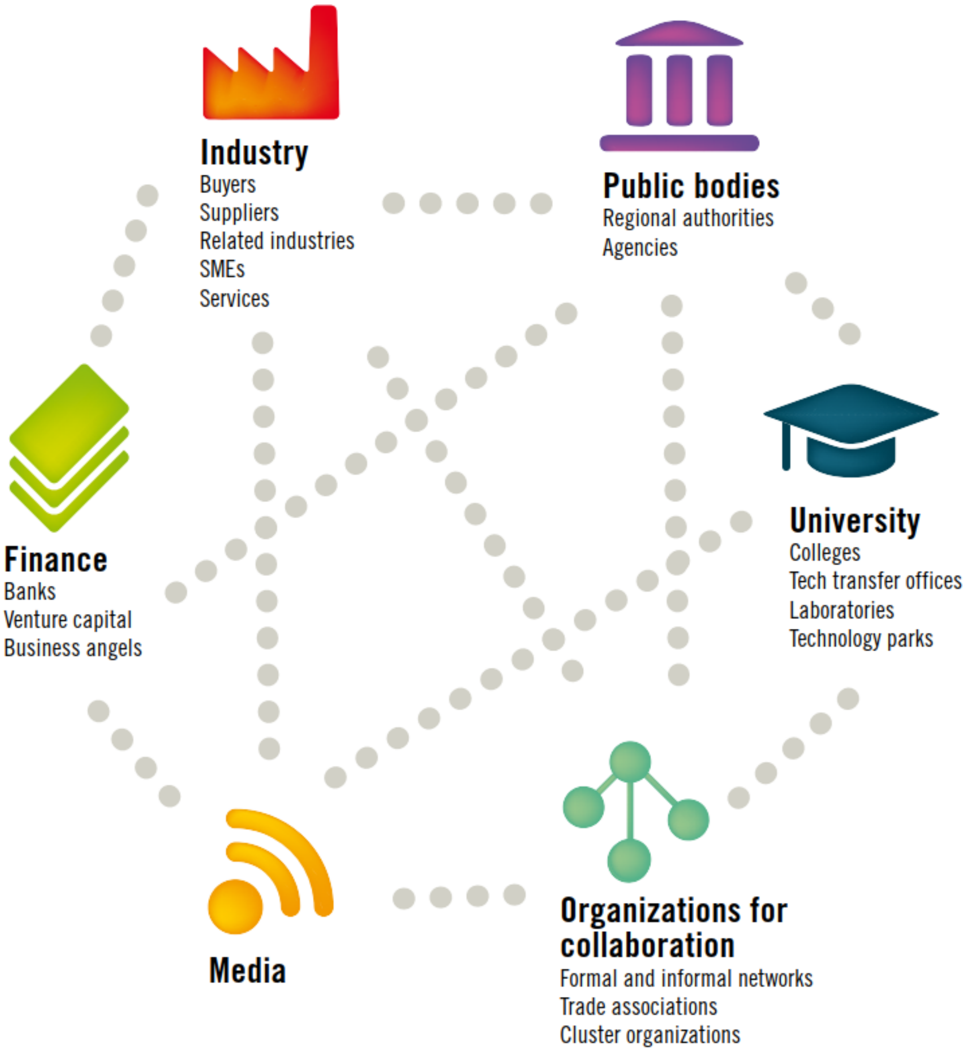

Figure 2. Cluster factors model (Sölvell 2008)

The level of dynamics and the amount and quality of linkages between cluster actors differ enormously across clusters as does their linkages to international markets. Companies in dynamic clusters share many activities such as market research and product development through cooperation and they operate more efficiently as critical resources and capabilities are accessible through networks within the cluster. They are also able to achieve higher levels of knowledge creation and innovation more rapidly and at a lower cost. (Sölvell 2008.)

The term University-Business Innovation Cluster is used in this study to emphasize the importance of the involvement of higher education institutions in cluster consortiums as creators of innovation and knowledge by offering businesses creativity and experimentation with reduced costs and risks.

1.4 Research Problem and Questions

This study is motivated by the importance of understanding the emerging IoT development space and describing the sources of funding and support which are available for developing and commercializing the sector. The objective of this study is to identify sources of support for the IoT Rapid-Proto Labs project after EU project funding ends in 2020. The long-term success of the IoT Rapid-Proto Labs project is dependent on understanding the factors and facilitators of success and sustainability of University-Business innovation clusters and the different funding options and models for them.

The main research problem in form of a question is: What are the sources of support within the IoT industry available for the IoT Rapid-Proto Labs project after EU project funding ends in 2020? The supporting sub-questions to this are:

1. What are the success factors in University-Business Innovation Clusters?
    a. What are the specific success factors in European IoT University-Business Innovation Cluster?
2. What factors contribute to sustainable University-Business Innovation Clusters?
    a. What factors support sustainable European IoT University-Business Innovation Clusters?
3. What are the financing and funding sources for University-Business Innovation Clusters?
    a. What are the specific financing and funding sources for European IoT University-Business Innovation Clusters?

The international context of the study is that IoT Rapid-Proto Labs is a European transnational project with project partners in Finland, Germany, Italy and the Netherlands. Of the seven expert interviews conducted for this study six represented innovation clusters with transnational activity.

1.5 Structure of This Study

The first section of this study outlines the needs and objectives of this study, background of the sponsor project and definition of University-Business innovation clusters. The second part of the study reviews and analyses relevant literature introducing key topics that are relevant to the research questions and used to outline the questions in the qualitative interviews. The conceptual framework of this study is also explained.

In chapter three, the research methodology is explained, and the research methods, strategy, techniques and procedures are described. The chapter explains the choice of case study research as a research approach and justifies the data collection and data analysis methods.

Chapter four includes the results of the study and in chapter five the recommendations for the sponsor project are explained together with the implementation of them. Chapter six includes the conclusions from the study, suggestions for further research and personal learning reflections of the researcher.

2 Literature Review

In this chapter of literature review the initial IoT theories is discussed and the European IoT market reviewed in subchapter 2.1. The theoretical framework of University-Business Innovation Clusters, as well as the paradigm of Open Innovation that supports the theoretical framework is reviewed in subchapter 2.2. The conceptual framework that connects the literature review to the structure of this study and the research questions is presented in subchapter 2.3.

2.1 What is Internet of Things

The term “Internet” refers to the vast category of applications and protocols founded on sophisticated and interconnected computer networks, that consecutively serve billions of users globally. The Internet of Things combines the physical realm with human-made virtual environments. (Buyya & Vahid Dastjerdi 2016.)

The evolution of the Internet is presented in Figure 3. Originally in the 1960s the Internet was perceived to interconnect computers between themselves and transmit simple messages with limited data exchange capability. The creation of the world wide web of information (web 1.0) was enabled by the linking of documents in 1989. In the early 2000s, the Internet evolved towards a universal communication technology (web 2.0) enabling the transfer of voice, video, or information content, and user-generated content in social media. Supported by the existing communication technologies such as the Internet, the Internet of Things (IoT) represents the next phase of digitalization where all objects and people will be interconnected through private, public and industrial communication networks, and report about their status and the status of their surrounding environment. Kevin Ashton (Massachusetts Institute of Technology’s Auto-ID Center in Boston) is often credited to the first use of the term Internet of Things. In 2009 while employed by Protect&Gamble, he mentioned the necessity of an Internet for Things as a standardized way for computers to capture and analyse information from the real world. (European Commission 2016.)

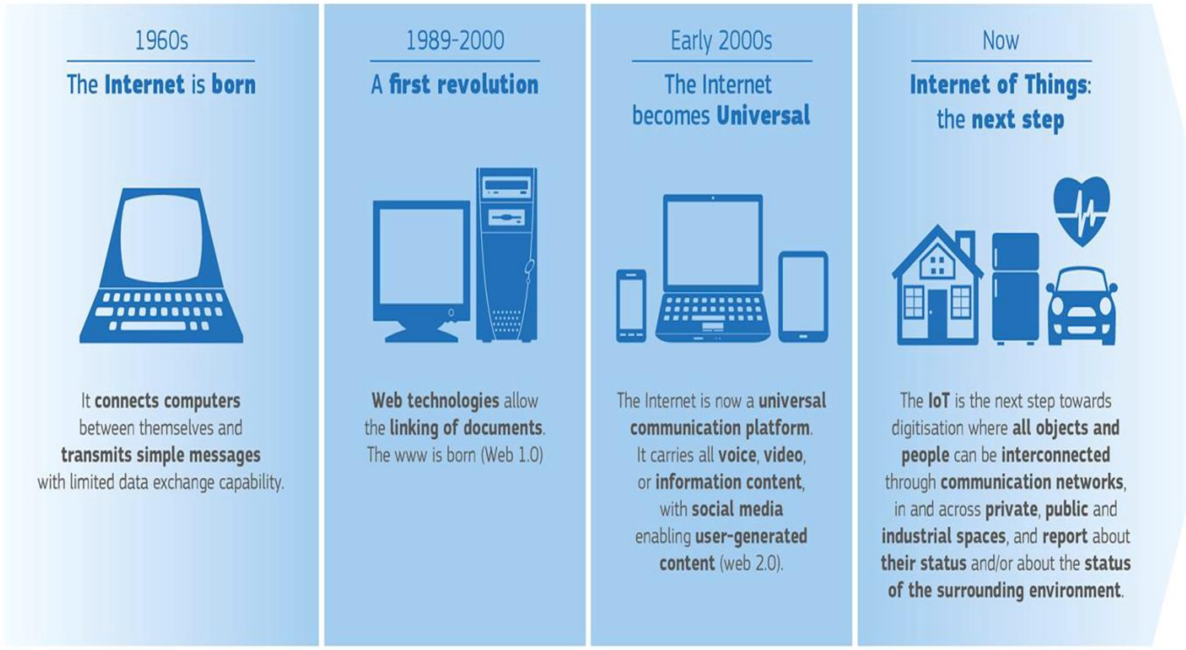

Figure 3. The Evolution of the Internet (European Commission 2016)

The technical definition of the Internet of Things comprises small devices, that all have their own Internet Protocol (IP) address and are connected to other similar devices via the Internet. But in practice, many of the small devices advertised as part of the IoT do not have unique IP addresses, are not connected to the existing Internet or even to other devices. This suggests that the IoT does not only connect things to things, it also involves autonomous operations, devices that can operate largely on their own, without much human interaction. And even the devices that are connected to other devices, do not have connections with all other devices in the IoT. The Internet of Things consists of multiple networks of devices, that each have a unique connection to specific industries or applications. (Miller 2015, 2-8.)

The devices the IoT can connect include home electronic devices such as smart televisions and streaming media servers, medical devices such as pacemakers and heart monitoring devices, automobiles including self-driving cars and residential automation devices such as smoke detectors and alarm systems. All these things are able to connect to one another and contain either a sensor that collects data or can perform a specific task, or both. Once enough of these devices come together, they create a coherent system which will act with its own type of intelligence, without the requirement for human interpretation and interaction. Every connected device within the IoT becomes something greater than any individual device by itself, because everything is communicating with everything else in an intellect, automated fashion and every device connects to other surrounding and relevant devices to share the data they have collected. An ambient intelligence is created when multiple devices act in unison to carry out everyday activities and tasks using the information and intelligence embedded into the network without requiring help or interaction from people. The connected devices that contain sensors register conditions in the world around them and transmit the collected data to other devices that are hardwired to perform specific actions. These action devices perform the tasks they are programmed to perform, and the sensor devices measure the results of those tasks. This creates a self-correcting cycle that becomes smarter over multiple iterations. (Miller 2015, 8-9.)

For the data collected within the IoT to be useful, it must be capable of being acted upon. The data becomes even more useful when data from differing kinds of devices are combined in creative ways. This is referred to as big data, a term for large amounts of data, data sets so large that they cannot be managed with traditional relational database technology. New processes that can make connections and correlations from this wide amount of data that result in intelligent decision-making must be developed to seize the full potential of the IoT. (Miller 2015, 35-37.) The IoT Information Value Cycle demonstrated in Figure 4 explains the discrete but connected stages where the information collected creates a never-ending process that allows perpetual learning. IoT devices and sensors are used to collect data from business activities of companies, the data is then analysed and used to gather insights on possible production delays, maintenance capacities, customer behaviour and so forth. Based on these insights, companies can make decisions and act, for example automate part order processes or notify technicians of need for physical inspections. (Deloitte 2018.)

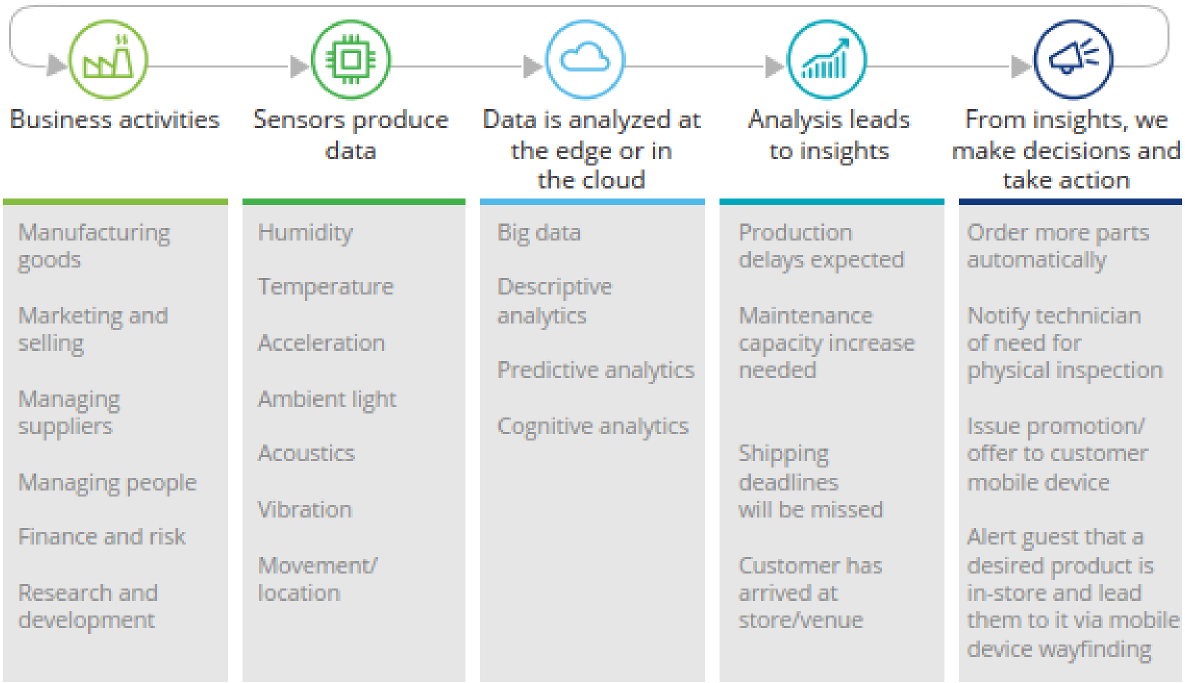

Figure 4. IoT Information Value Cycle (Deloitte 2018)

Investments in Internet of Things technology and applications can generate meaningful economic revenue for the enterprises in three ways; by enhancing enterprise financial performance, by enhancing enterprise process economics and by improving performance. Enterprise financial performance includes the fundamental economic drivers of revenue, expenses and assets. The remote sensing capability of IoT devices and applications enables production companies to drastically minimize the lead-time between equipment breakdown and repair, thus extending the utilization of the production equipment. As IoT provides a much deeper understanding on how consumers and companies use products and services over time than presently, it may potentially unveil unmet needs and help companies design new products and services that address them. Enterprise process economics including three core processes that steer organizational operating performance (customer life cycle, product life cycle and facility life cycle) can be drastically enhanced by investments and employment of IoT technology and applications. Early investments in IoT have boosted the performance of the facility life cycle in many companies that have installed and connected sensors to increase the utilization of their facilities and extended their useful lives through more effective monitoring of conditions. IoT technology enables companies to monitor product use patterns, producing them valuable insights they can use to innovate new products that can create even more value for the customer. This will accelerate adaption of new products and services and lower the cost of acquiring new customers. (Hagel III 2014.)

IoT presents significant opportunities for providers and end users, and it has the potential to generate new sources of revenue. IoT enables companies to evolve from product producers into service companies. The data generated by IoT can produce many insights and offer considerable economic value. (Liu 2017.) For the customers, the main advantage the IoT offers will be new services enabled by connected products and backend services based on big data. The potential benefits of IoT are significant for manufacturers also. Currently most manufacturers do not hear about their products once they leave the factory. The traditionally disconnected asset lifecycle can be transformed into to a fully connected asset lifecycle due to the potential to connect practically any kind of device or product to the IoT. (Slama, Puhlmann, Morrish & Bhatnagar 2016, 3-4.)

IoT will also drastically effect sales and marketing as it provides information on the demands and behaviour of product users, as well as new insights into usage patterns and value creation. Sales can identify cross- and up-selling opportunities assisted by analysis of product usage patterns. Significant revenue after the sale of the initial product or service can be generated with the combination of physical products and digital services. Connected products also facilitate product resale and retirement activities, thus reinforcing customer retention. (Slama et al. 2016, 4-5.)

2.1.1 IoT Industry Market

Regionally, Western Europe, North America and Greater China constituted 67% of the overall Internet of Things installed base in 2017. (Gartner 2017.) According to International Data Corporation’s forecasts presented in Figure 5, IoT spending for 2019 was expected to be 726 billion USD, the industry spending most on IoT solutions was predicted to be discrete manufacturing with 119 billion USD followed by the consumer market (108 billion USD) lead by smart home and connected vehicle use cases. Process manufacturing was predicted to spend 78 billion USD, followed by Transportation (72 billion USD) and Utilities (61 billion USD). (i-SCOOP 2019.)

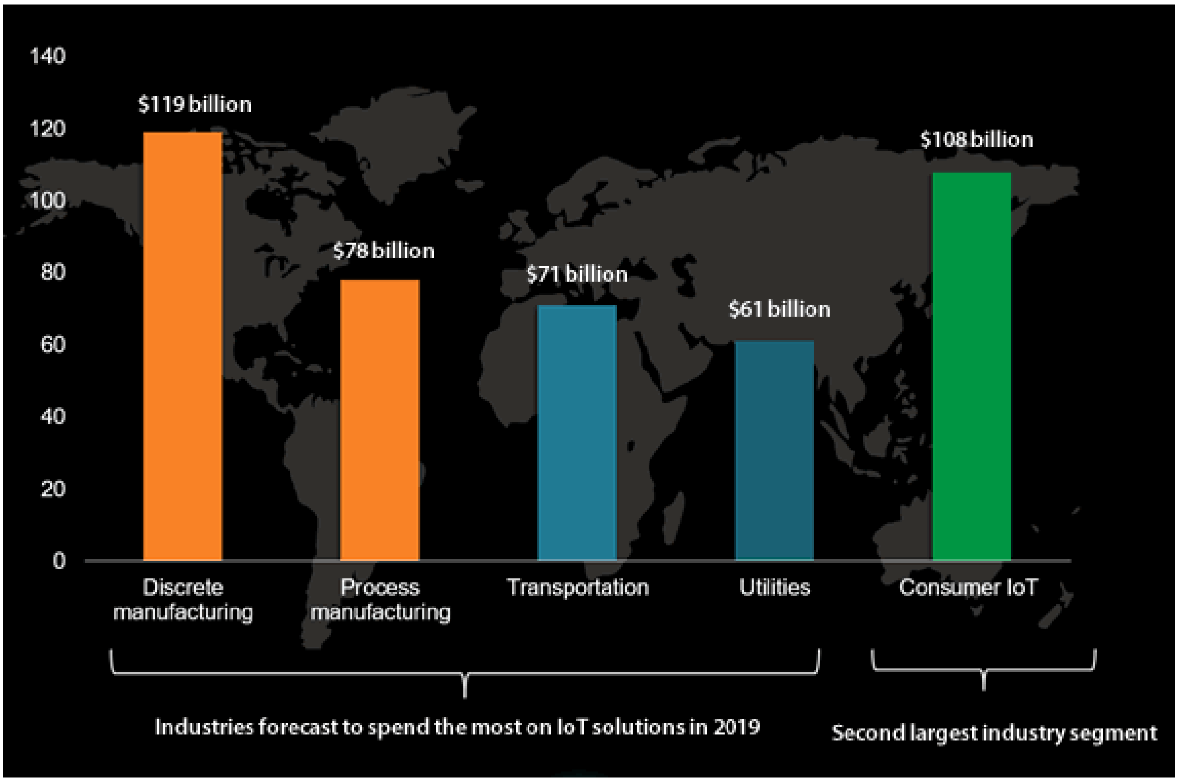

Figure 5. IoT Spending 2019 (i-Scoop 2019)

According to the forecasts the worldwide IoT spending will surpass the 1 USD trillion mark in 2022 with discrete manufacturing, process manufacturing and transportation accounting for nearly a third of global IoT investments in 2023. Consumer spending is expected to become the largest source of IoT spending by 2023, overtaking discrete manufacturing. The forecast of five-year compound annual growth rate (CAGR) across all industries is 16.8%. (i-SCOOP 2019.)

The fastest growth in IoT spending in 2019 was predicted to happen in Latin America (CARG 23.1%) and the Middle East and Africa (CARG 19.5%). The forecast period of 2017 - 2022 predicts the fastest IoT spending growth over are all in Latin America with Mexico in the first place (CARG of 28.3%), followed by Colombia (24.9% CARG) and Chile (23.3% CARG). USA (194 billion USD) and China (182 billion USD) were predicted to be the largest IoT investors in 2019, followed by Japan (65,4 billion USD), Germany (35,5 billion USD), Korea (25,7 billion USD), France (25,6 billion USD) and the UK (25,5 billion USD). (i-SCOOP 2019.)

2.1.2 IoT Market Segments

IoT market segments can generally speaking be divided into three comprehensive categories: enterprise/industrial, consumer and services/public sector as pictured in Table 1. The enterprise/industrial segment is the fastest growing segment, it has been predicted to capture more than 50% of global IoT spending by 2020. The segment includes relatively complex and rich data sets and fewer devices than the consumer segment. Main use cases include condition-based monitoring and demand and supply synchronization. The consumer segment is typically implanted in customer experience and lifestyle enhancement, use cases include smart home devices, connected vehicles and personal lifestyle monitoring. The services/public sector segment is generally a mixture of the two segments descried before in terms of richness and complexity of the data and the number of devices. Common use cases include smart cities and patience surveillance. (Deloitte 2018.)

Table 1. IoT Market Structure (Deloitte 2018)

	Enterprise/industrial	Consumer	Services/public sector
Representative value opportunities	• Planning and inventory • Factory and operations • Supply network and logistics • New business models • New products and product development • Asset management	• Customer experience • Channel connectivity • Aftermarket support • New products and extensions • Lifestyle enhancement	• Health care delivery • Commercial building energy management • Public sector safety • Public sector traffic management • Crop yield management
Representative use cases	• Demand and supply synchronization • Quality sensing and prediction • Condition-based monitoring • Dynamic routing and scheduling	• Smart homes • Remote appliances • Connected cars • Personal lifestyle monitoring • Personal asset tracking	• Smart buildings • Smart cities • Smart irrigation • Patient surveillance • Smart law enforcement
Additional features	• Manufacturing operations and product driven • Private cloud primarily • Hybrid architecture • Fewer devices • Relatively complex data sets • B2B channels	• Customer and product driven • Public cloud primarily • Millions of devices • Simpler data sets • B2C channels	• Public sector, services driven • Public/private cloud mix • Variable data set complexity • Medium number of devices • B2B2B, B2B, B2C channels
Projected global IoT spending share by 2020	50–60%	20–25%	20–25%

Based on the analysis of 1 600 on-going global, publicly announced enterprise IoT projects excluding consumer IoT projects presented in Figure 6, 23% the IoT projects identified are connected to Smart City (367 projects), followed by Industrial settings (265 projects, 17%) and Connected Building projects (193, 12%). Other segments include Connected Car (11% of projects), Smart Energy (10%), Connected Health (6%), Smart Supply

Chain (5%), Smart Agriculture (4%) and Smart Retail (4%). 45% of these projects are taking place in America, followed by Europe (35%) and Asia (16%). (Scully 2018.)

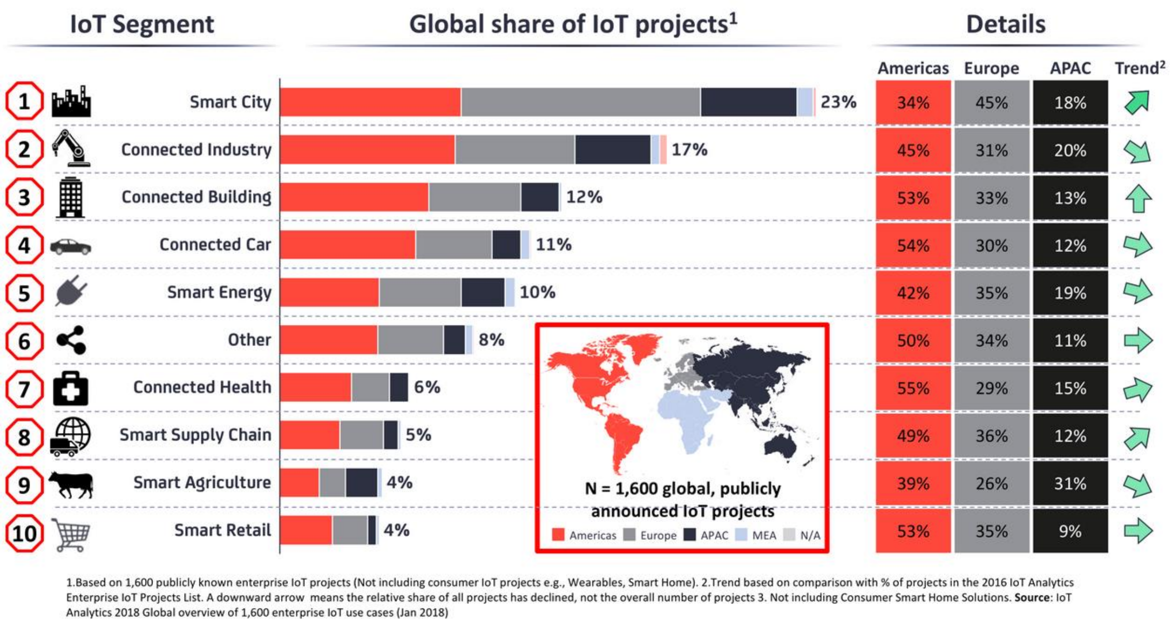

Figure 6. 2018 ranking of Top IoT Segments (Scully 2018)

There are significant differences in individual regional IoT segments. Most of the Smart City projects are taking place in Europe (45%), while the majority of the Connected Health (55%) and Connected Car (54%) projects are in the Americas, particularly in North America. The Asia-Pacific region is strongly focusing in Smart Agriculture projects (31%). The main value driver for most of the identified IoT projects is cost savings (54%), while 35% are aimed to increase revenue (by for example offering new products and services connected to the IoT) and 24% are used to increase overall safety (by for example offering enhanced monitoring systems with real-time alerts and notifications). (Scully 2018.)

The largest segment of IoT projects that have been identified is Smart City (23%). The most popular Smart City use case is Smart Traffic, which includes projects such as parking systems, traffic monitoring and control, bicycle sharing, and smart bus lanes and bus shelters. Other Smart City initiatives include utilities, environmental monitoring, public safety and lighting. The largest number of Smart City projects identified (164 projects, 45% of all Smart City projects) are in Europe. (Scully 2018.)

17% of all global, publicly announced enterprise IoT projects identified are related to Connected Industry, which includes a wide range of connected devices and applications both inside and outside the factory. The most popular Connected Industry use cases are equipment monitoring in non-factory environments such as drills, forklifts, cranes as well as entire mines and oil fields. The second most popular Connected Industry application is Smart Factory, automation and control projects including holistic solutions such as production floor monitoring, wearables on the shop-floor and automated quality control systems. (Scully 2018.)

2.1.3 Leading IoT Companies

The market of IoT platforms has two main categories: Industrial IoT platforms that are firmly connected to infrastructure (Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) platforms) and Infrastructure agnostic industrial IoT platforms. Microsoft is a clear leader in the IaaS market regarding Industrial IoT offerings, while Amazon, IBM and Google also provide IaaS and PaaS solutions for industrial companies. The Infrastructure agnostic industrial IoT platforms are deliberately vendor-agnostic regarding the IaaS and cloud backend layer. The leading companies of the Industrial automation include Siemens, GE and PTC. The leading Industry 4.0 Vendors are presented in Figure 7. (Wopata 2019.)

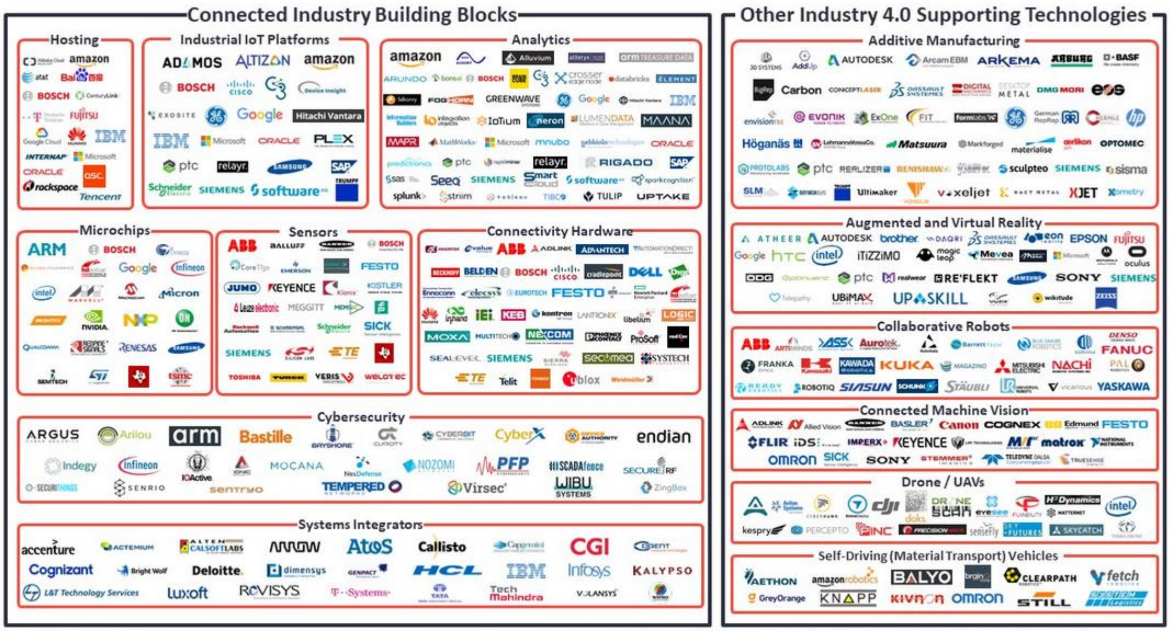

Figure 7. Leading Industry 4.0 Vendors 2019 (Wopata 2019)

Microsoft is also the most popular hosting partner for many Industry 4.0 companies, including major manufacturing end users and suppliers such as Siemens, PTC, GE and Emerson. Both end users (e.g. manufacturing facilities) and suppliers (e.g. OEMs and industrial automation companies) have partnered with Microsoft to develop and run missioncritical on-promise SCADA (Supervisory Control and Data Acquisition) and MES (Manufacturing Execution System) applications for many years. (Wopata 2019.) Microsoft announced in April 2018 a 5 billion USD investment into IoT technologies over the 4 following years. Most of these investments are expected to be directed to cloud services, IoT operating systems and analytics. (Lueth 2019.)

One of the leading Industry 4.0 companies is Festo, a German supplier of electrical, pneumatic and drive control technology that serves customers in both process and discrete industries around the world. Festo has been actively participating in several Industry 4.0 working groups and has focused on developing communication standards that insure vendor interoperability. HMS has become one amongst the leading Industry 4.0 companies since it acquired eWON in 2016, which specialises in industrial IoT connectivity. Their product portfolio has evolved into a selection of industrial connectivity from the original selection designed as a remote access solution for control engineers and OEMs seeking to remotely monitor and program PLCs (Programmable Logic Controllers). Accenture has become a leading Industry 4.0 strategy and implementation consulting company and it is considered a prominent thought-leader on digital transformation. Accenture encompasses a strong footing in Industrial IoT within the process industries and has formed strong partnerships with many large industrial vendors such as Schneider Electric and Siemens. ABB, a specialist in industrial automation and robotics, is amongst the biggest companies to offer a line of collaborative robots. ABB has a strong existing robotics business and has recently acquired the discrete industrial automation supplier B&R, making it well-positioned to answer to the growing demand for collaborate robots as manufacturers seek more flexible and affordable ways to automate production processes. (Wopata 2019.)

To study the patent landscape of the Internet of Things, Relecura has analysed a total of 191 595 at the time active published patent applications, of which 89 399 had been granted. These patent applications addressed various technologies and applications associated with IoT. According to the report Samsung was the top IoT patent holder with a 5,65% share of total applications. They had applied for 7 702 patents, of which 2 874 had been granted. Samsung was the key patent holder in most IoT technology sectors, and its patents addressed multiple application areas. Other top patent holders were Qualcomm (3,21%), Intel (2,35%), Nokia & Alcatel-Lucent (1,64%) and Huawei (1,52%). China, USA, Europe, Korea and Japan account for 75% of the patent filings comprising the key IoT market. The top IoT sub-technologies for the patent applications were Communication protocols supporting network applications, Arrangements, apparatus, circuits or systems for digital transmission, Wireless network topologies, Data switching networks and Providing wireless communication services to user via network. The key companies selling and/or transferring patents were Broadcom (555 patents), HP (163), Flextronics (156), IBM (134) and Motorola Mobility (119). (Relecura 2018.)

2.1.4 Growth of Market

The Internet of Things is predicted to become more embedded in our everyday life. It will soon be taken for granted that almost all the devices we own, such as cars, TVs and watches will be able to connect to the Internet and communicate with one other. Also, in industry companies are expected to increasingly implement on IoT deployment as tools and machinery are more and more intelligent and connected, they generate data that drives efficiency and enables predictive maintenance. Nearly all car manufacturers are working on virtual assistants that help drivers operate their vehicles more safely and conveniently. Other IoT trends that are predicted to generalize include edge computing, Artificial Intelligence and 5G. Edge computing refers to algorithms that are run at the edges of a network, usually at the point where the network connects to the real world, such as within sensors and cameras themselves. The primary task of Artificial Intelligence within the IoT environment is training machine learning algorithms to detect deviations within the data that might indicate opportunities for efficiency or provide early warnings of possible problems. 5G networks will broaden the capacity and availability of IoT as they can operate 20 times faster than the existing mobile data networks enabling concepts like smart cities where civic amenities are connected, and the data is analysed to create cleaner and more efficient urban living environments. (Marr 2019.)

The size of the IoT market is expected to grow from 679.4 Billion USD in 2016 to 2,108.2 Billion USD by 2023. The global market is predicted to gain CARG of 17.56% between 2016 and 2023. Asia-Pacific accounted for the highest share (34%) in the global IoT market in 2016 and is expected to continue on top until the end of the forecast period. China is forecast to possess the largest market size within the Asia-Pacific IoT market and India is forecast to grow with the highest CARG of 24.24% over the forecast period from 2016 to 2023. Europe is forecast to be the second largest IoT segment in 2023 due to the rising adaptation of connected devices and the rising personal disposable income of population. (Kenneth Research 2019.)

The global IoT market is divided into components and software, the software segment is forecast to grow with highest CARG of 20.24% from 2016 to 2023. From the various application segments of the IoT market including consumer electronics, manufacturing, transportation and logistics, healthcare, retail and others, the consumer electronics segment is forecast to account for the largest share of 28.4% in overall IoT market by the end of 2023. The healthcare sector is also expected to see a significant growth due to the rising demand for remote monitoring of patients and the growing penetration of tele-medicine services in both developed and developing regions around the world. (Kenneth Research 2019.)

2.1.5 The European IoT Market

Europe is facing several large-scale transformations in several social areas driven by factors including climate change and aging demography placing immense demands on the public sector in many areas of its responsibility including environmental protection, education and elder care. (Ravindra 2018.) The European Commission (2018b) actively cooperates with industry, organizations and academic institutions to unleash the potential of the IoT technology across EU Member States and beyond. The value of the European IoT market could be higher than one trillion euros by 2020. Currently less than 1% of objects are connected to the Internet. The number of IoT connections within the EU has been estimated to increase from approximately 1.8 million in 2013 to nearly 6 billion in 2020, the number of objects connected globally has been estimated to reach 26 billion by 2020. This growth in connectivity is anticipated to reshape industry structures and convey vast economic benefits from a series of solutions addressing societal challenges, such as energy-saving smart streetlights, intelligent transport systems that reduce travel time and accidents and health monitoring solutions that enable independent living for senior citizens and people with chronic conditions. (European Commission 2016.)

According to a survey of 2,280 executives in more than 60 countries organized by PwC and Oxford Economics, Western European organizations are well-positioned to outpace organizations from other regions in the progress towards digital transformation. 53% of the European respondents said that they already have realized value from their digital investments in disrupting their own or other industries and 43% have realized value from their digital investments in innovating their products. The strategic goals of Western European organizations driving technology adaption and implementation are presented in Figure 8, and include modernizing the brand, becoming more efficient, changing their core business model and breaking into new markets. They are more focused than others to improve the speed and efficiency of their core businesses. (Greif 2018.)

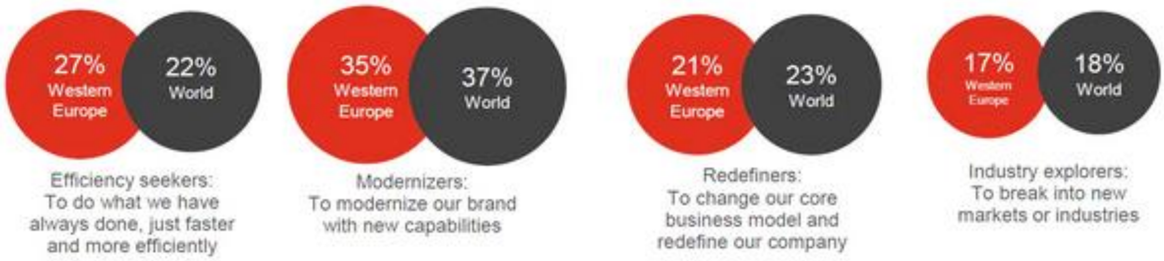

Figure 8. Goals for Digital Transformation (Greif 2018)

A research by Bain & Company of 500 executives in 2016 suggested that the business executives in Europe are more determined and positive about their plans to deploy and integrate IoT solutions, particularly in industrial and commercial applications, than business executives in North America. The research also suggested that a greater percentage of European executives intended to deploy IoT solutions over the five next years compared to their colleagues in other regions. 27% of European executives were implementing or had already implemented IoT and analytics use cases, as opposed to 18% of US executives. 25% of the European respondents planned to implement IoT solutions in multiple cases and integrate them with their IT systems by 2020, as opposed to 16% of the US respondents. These numbers, presented in Figure 9, suggest that European organizations are further along in integrating and scaling IoT solutions and applications, moving from experimentation to real commitment and scale deployment. (Schallehn, Schertler & Schorling 2017.)

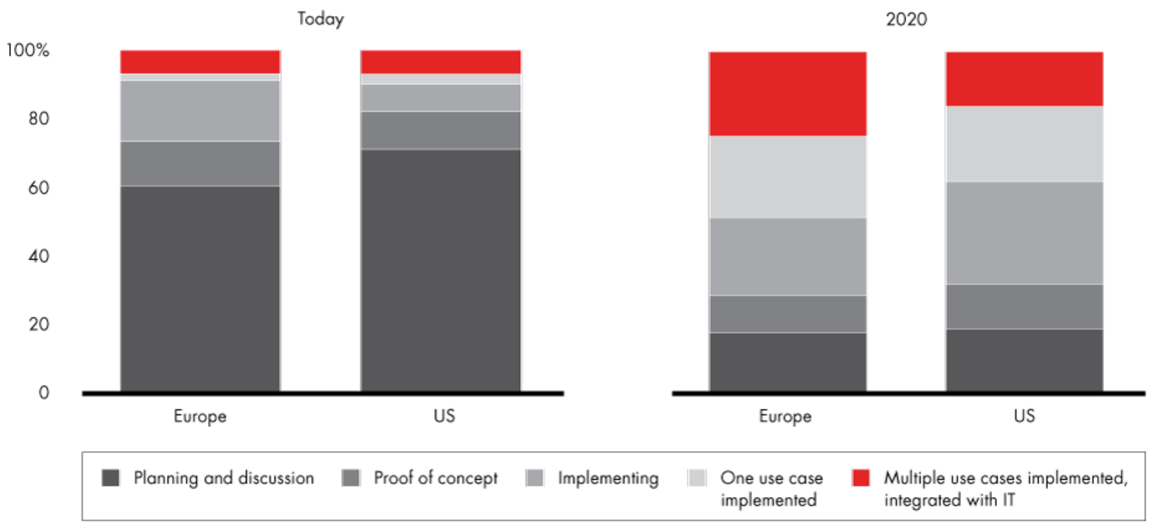

Figure 9. Adaptation of IoT Solutions (Schallehn, Schertler & Schorling 2017)

According to the research by Bain & Company European and North American business executives appear to have different incentives for IoT investments. Among executives who emphasized cost reductions, 65% of European executives strived to improve the quality of existing products based on IoT technologies and advanced analytic, while only 35% of the American executives rated such improvements as a priority. The research also found that some industries (automotive, retail, industrial and buildings) in Europe were devoting more of their IT budgets to IoT compared to their counterparts in North America. Vertical solutions are likely to develop more rapidly in Europe than in other regions as vendors strive to meet this demand. (Schallehn et al. 2017.)

Market spending on IoT in Western Europe is expected to grow from approximately 147 billion USD in 2017 to over 274 billion USD in 2021. Germany is the biggest investor in IoT in Western Europe due to the vast number of manufacturing companies and the large contribution of manufacturing to Germany's GDP. In Germany, the focus of the IoT investments is cost control and efficiency gains. France was one of the highest ranked countries in terms of IoT technology related funding activity in 2015 and 2016. Investments in France spanned network solutions, smart home, automotive, health solutions and developer tools. (Earls 2018.)

In Germany and the UK there is a great focus on IoT and a willingness to invest in it. Companies across Italy consider the improvement of supply chain management as the biggest driver for implementing IoT technology and solutions. The Nordic countries is the most advanced region in Europe for IoT adaptation, where the main motivators for IoT investments are cost reduction and the development of connected products and services. The landscape in Western Europe is creating a positive investment climate, companies are generally willing to invest in optimization due to low interest rates and recent economic growth. (Earls 2018.) The European Union acknowledges the importance of focused research and testing of the IoT to support the development and adaption of the technology. For the period from 2014 to 2020 under Horizon 2020, the European research and innovation programme, the EU is investing almost 500 million EUR in IoT related research, innovation and deployment. (European Commission 2018a.)

2.1.6 Leading European IoT Companies

European organizations are committed to growth, inorganic or otherwise, and are competing to obtain the necessary skills and knowledge. Siemens has invested more than 8 billion Euros in IoT related acquisitions, including 4.2 billion Euros for electronic design software developer Mentor Graphics. Other European companies have also made multibillion-euro investments to expand their IoT products and solutions portfolios. Schneider Electric, the French multinational energy management corporation, has invested more than 8 billion Euros creating its energy-efficient platform, EcoStruxure. ABB, the Swedish-Swiss high-tech engineering multinational corporation, is also investing in smart grid space expanding its capabilities for managing electrical equipment at power plants and on utility grids. (Schallehn et al. 2017.)

SAP, the German multinational enterprise-software company, has acquired Plat.One, which has an IoT platform connecting smart devices across transportation and manufacturing environments, and the company is planning to invest approximately 2 billion Euros in IoT over the subsequent few years. German automobile manufacturers Audi AG, BMW Group and Daimler AG have invested 2.6 billion Euros to acquire digital mapping company HERE from Nokia to assist them compete in the rapidly evolving field of location intelligence, one of the key components of autonomous driving. (Schallehn et al. 2017.)

2.1.7 Major Challenges for IoT Development

The Internet of Things has the potential to offer solutions to several major world problems, by bringing better healthcare, more efficient transportation systems, new jobs, and even a cleaner environment thus possibly a way to effectively deal with climate change. One of the largest challenges in creating this global IoT is connecting everything together. Local IoT networks must be connected to a worldwide network and thus to other local networks. The sheer size of the endeavour may be a challenge, as is getting a range of various network technologies to connect with each other and with IP-based devices on the Internet. (Miller 2015, 282-284.)

The Internet of Things is in many ways here today, although not in its most developed form. Many of the devices and parts are in place, waiting for the final network to form. There are over a billion devices that contain embedded sensors and can capture all forms of data. For the future these devices are needed to connect to the Internet, or to each other, for more intelligent purposes. Connecting everything together within the Internet is technically complex and getting competing companies to cooperate can be even more complex. The cost of technological advancements is also a factor delaying the progress. It takes time for economies of scale to be reached and the value proposition for connected devices to be established. It will presumably take a decade or several decades before most items and systems are compatible with and connected to the IoT. (Miller 2015, 11-12.)

2.1.8 Need for Multi-disciplinary Competences

Companies in industries with short technology life cycles (e.g. ICT, electronics and telecommunications industry) rely on cooperation with external partners to sustain with new developments in and around their industry. Companies in industries with long technology life cycles and strong protection of intellectual property rights (e.g. pharmaceuticals, chemical and materials industries) seek cooperation with external partners to sustain with research. Companies in industries where patents are important but may be more easily circumvented (e.g. the transport equipment industry and the fast-moving consumer goods industry) collaboration is used to sustain with new developments, seeking technologies or products that have proven their market potential which may be improved, scaled up and commercialized. (OECD 2008, 10.) Customers are now looking for end-to-end solutions that evolve with their operational needs. As single companies cannot specialize in all aspects of IoT it is wise to join innovation clusters that have a shared vision and objective offering specialist knowledge and skills. Other advantages of innovation clusters include reduced research and development costs, accelerated time to market, improved return on investment (ROI) for every stakeholder and enhanced customer experience. Customers will also have continued support and innovation across the entire value chain for their investments. (Slama et al. 2016, 192-193.)

The Fourth Industrial Revolution is heavily knowledge-based and makes education policies of absolute importance as new competencies are intensely needed. Partnership between higher education institutions and enterprises is in a key role to ensure high competitiveness of industry in any sector or region. The graduates of higher education institutions must develop relevant multi-disciplinary first-hand experience for the labour market. (Lee et al. 2018.) The future development of the European economy will be based on the ability of large enterprises, SMEs, Start-ups, public administrations and research organizations to extract insights from information gathered through next-generation digital infrastructures and transform them into products, services and experiences to create new jobs. This economic growth will boost the EU's productivity and competitiveness. (AIOTI 2018.)

2.2 University-Business Innovation Clusters

The Fourth Industrial Revolution will affect job specifications and professional competencies as business models and technologies develop. Educational institutions need to acknowledge that the most successful organizations of the Fourth Industrial Revolution are those that can recognize the centrality of people in the organizational life. Higher educational institutions need to support the adaptation and research and development of new technologies to increase the technological capacity of organizations. They must also support the implementation of human development strategies to make companies more creative and flexible. Educational institutions must be responsive, tentative and perceptive. (Lee et al. 2018.)

2.2.1 Innovation and Open Innovation

Innovation is a central theme in the study of economics, technology, engineering and sociology. Currently the questions asked in research focus on how to innovate and the ways innovation processes can be managed. Companies must be able to adapt and evolve different innovation techniques if they wish to operate in the competitive market defined by the globalization of competition, as well as major financial and demographic challenges. (Gawarzynska 2010, 1-9.)

The paradigm of open innovation that supports the theoretical framework of University-Business innovation clusters includes companies using external as well as internal ideas, and external and internal paths to markets, as the companies look to advance their technology. The open innovation model is the opposite of the traditional closed model, where companies rely mainly on their internal innovation processes and R&D department. Open innovation is a more dynamic and informal model where innovation relies on the collaboration with external knowledge assets, and academic research is widely used. The success of open innovation is dependent on the open character of the company’s business model, open innovation must be at the core of the company’s business strategy. It must acknowledge the potential use of external technology and knowledge in the value creation process. The advantages of open innovation include access to a broader repertory of technologies and knowledge, more flexibility and responsiveness with lower costs, and the possibility to explore new growth opportunities with less risk. Possible disadvantages include the additional costs of managing collaboration with external parties and the dependence on them. Risks associated with open innovation include theft of intellectual property (IP), as unique knowledge may be revealed to external partners that might later become potential competitors. (OECD 2008, 11-41.)

2.2.2 Innovation Clusters

Due to globalization companies must be competitive in international markets, which requires flexibility, abilities to adapt to fast changing business strategies, and constant recombinations of specialized suppliers and other business partners. The importance of localized factors of production is reduced because of globalization. The commercial success of innovative products and services is dependent on linkages with clients and customers in foreign markets. (Simmie & Sennett 1999.) The most progressive leading companies recognize that collaborating with entrepreneurial Start-ups and SME's, and research centers can benefit them by providing product and business model innovation and creating an ecosystem of products and services to support and enrich the user experience for core products of the company. Start-ups and SME's partnering with large companies gain easier access to markets, capital and other resources. (Engel 2015.)

Studies have shown that innovation clusters offer their members a high level of competitiveness as they produce new knowledge and innovation and lower the costs of research and development, internal specialization and standardization. Participants of innovation cluster can respond to customer needs more accurately and quickly. Innovation clusters enable the coordination of efforts, financial resources and supply chains to create new products and technologies and output them to the market. The sustainable development of innovative clusters significantly depends on the access to advanced sources of scientific knowledge and technologies as well as the existence of civilized infrastructure of intellectual and financial capital. (Mazur et al. 2016).

Figure 10 demonstrates the key players and development factors for the creation of innovation clusters and their sustainability. Key development factors include talented, innovative people, infrastructure, development policy and business environment that enable cluster formation, sophisticated technology and financing. Key development players include R&D sector, SMEs and industry and a supportive public sector. Most often cluster initiatives start from the private sector spontaneously by global market pressure to domestic SMEs and their understanding of the necessity to cooperate. The lifecycle of innovation clusters consists of five steps. The first step is the analysis of cluster initiatives and planning the strategy, which is followed by policy learning and cooperation. The third phase, which is cluster development, leads to transnational cooperation, the fifth phase is cluster support activities provided by mature clusters. (Wagner et al. 2012.)

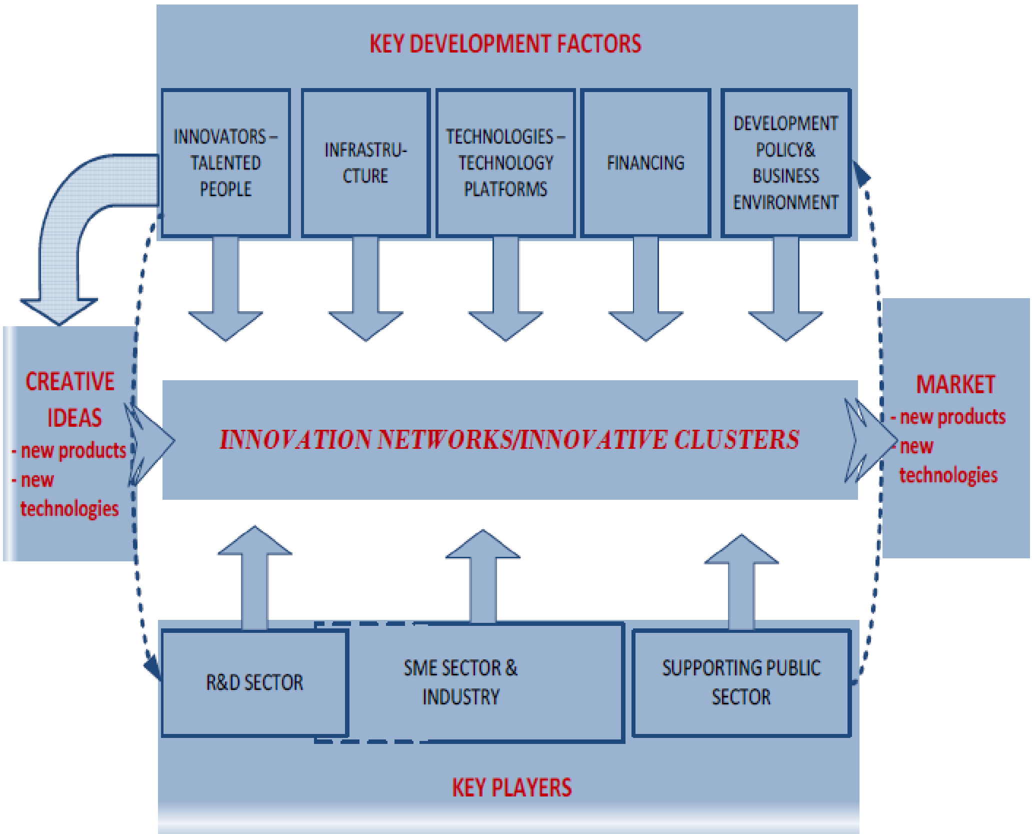

Figure 10. Development of innovation clusters (Wagner et al. 2012)

2.2.3 Members of Innovation Clusters

Large players, such as large multinational companies and large research and technology organizations are considered natural counterparts to the start-up and development of policy-making initiatives as they are more visible and own clearer innovation strategies. Public bodies are frequently involved in IoT clusters as key actors in territorial development strategies and implement programmes due to their clear role and mandate in defining local and regional industrial and reindustrialization policies. Public bodies have a key role in defining the framework conditions in terms of regulations, environment, education, training and research and they provide specific support to internationalization initiatives. Case studies have demonstrated that public bodies are essential stakeholders and contributors to clusters but not essential to cluster's sustainability for at least two reasons: the uncertainty of endowment funds and operation funds over time and because of the limited sustainability of project work. However, case studies have shown that public bodies cannot support cluster attraction and aggregation or sustainability in the long run. (European Commission 2019.)

IoT cluster case studies confirm that SMEs are very important players in clusters and participation in clusters may strengthen their productivity, competitiveness and innovative capabilities. SMEs are as innovative as big companies, but due to their small size and financial weakness SMEs may not be able to cover on their own the cost of purchase of research results. Case studies have shown that clusters are capable of aggregating SMEs and boost their ability to perform on markets. Recent scientific literature acknowledges that Start-ups are an extremely important player in innovation, economic growth and job creation. The IoT innovation cluster study shows that Start-ups have a very particular relationship with IoT clusters, and they can take advantage of clusters only under certain conditions, the clusters need to take account of Start-ups' specific characteristics and needs. Start-ups are small and lack critical mass and are unable to allocate significant amount of funds to cluster fees and to allocate significant resources to open activities such as internationalization missions as they are putting most of their efforts into making the start-up phase a success rather than engaging in community building. Still Start-ups are very important to push forward the development of technologies as well as the topic of IoT itself, drive innovation and application adaptation in IoT. Start-ups are much more focused in their individual success rather than on their cluster membership and prefer ad hoc collaborations so IoT innovation clusters need to be made attractive to them in terms of advantages and of reduced associated costs such as membership costs or transaction costs. (European Commission 2019.)

2.2.4 Funding of Innovation Clusters

Most innovation clusters face the challenge of how to sustain the success of the cluster when the initial funding is running out. In most cases the solution is to gradually shift from public to private funding such as membership fees and consultancy fees. It may be a weakness for an innovation cluster organisation to be dependent on a single source of funding. The largest source's share of total funding is an indicator for this sensitivity, the higher this share is, the more dependent the cluster organisation is of its main funding source. Cluster organisations with multiple sources of funding that are approximately the same size are more adaptable to changes in the funding situation. Figure 11 demonstrates the share of public and private funding through a cluster lifecycle. (Lindqvist & Sölvell 2011.)

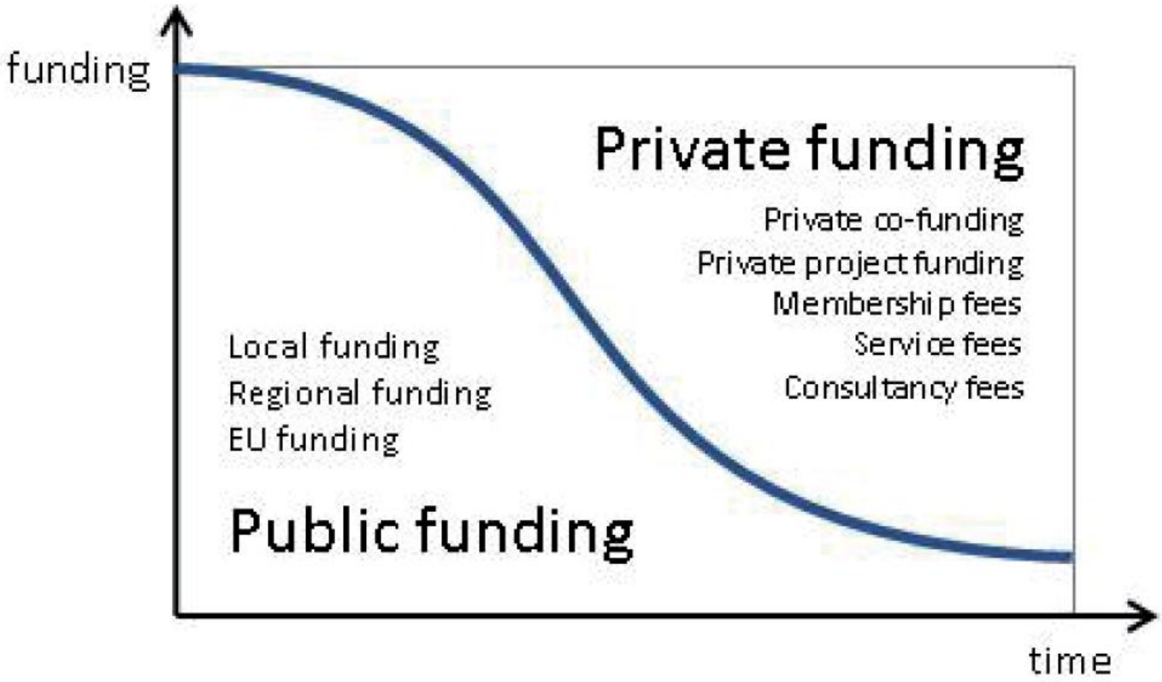

Figure 11. Evolution of Funding for a Cluster Organisation Over Time (Lindqvist & Sölvell 2011)

Initial funding endowment provided by cluster founders was confirmed to have been sufficient by the study on mapping Internet of Things innovation clusters in Europe (2019) to launch the collaboration and to secure the start-up phase of the innovation cluster, when membership fees and other financial resources became available. Many clusters that are participated by a public institution have a yearly contribution by EU, national, regional or local administration. Innovation cluster management see this contribution as strategic towards its mid-term sustainability. Higher education institutes and research organizations are necessary as innovation cluster partners, but there have been issues related to the stability of their resources and contributions over time.

Membership fees are considered very important since they are one of the mid-term sustainability factors. Many clusters differentiate membership fees according to member type (SMEs, large enterprises, research centers or higher education institutions). Membership fees by companies are closely related to the performance and value added offered by the IoT clusters since companies are very careful about the level and quality of benefits they receive from the cluster membership. The regular availability of public and private funding significantly influences the perspective and sustainability of the IoT innovation cluster. Some clusters recognize that they will never be able to collect all the necessary funding from industry subscriptions simply because the local industry base is too small, clusters need a robust industrial ecosystem to be sustainable. (European Commission 2019.)

Several innovation clusters engage in funded project work to sustain themselves. However, project work is challenging as while it creates an independent source of funding it also creates a potential misalignment of project objectives and cluster core business objectives. Also, the time scope of cluster strategies is often not aligned with project funding. Funded project work may also require co-funding which challenges the availability of additional resources. If project funding becomes dominating, the economic risk level of the innovation cluster organization increases. For these reasons some innovation clusters have made a clear decision not to build on external funding, but rather to sustain the cluster activity just through subscription and/or membership fees. (European Commission 2019.)

2.2.5 Obstacles and Impediments to Success of Innovation Clusters

A major challenge for IoT companies and IoT innovation clusters is the lack of individual and organisational competencies, skills and expertise. There is a huge need for relevant IoT know-how, about 70 000 additional skilled workers are needed in the next years. In economic and sector cycle phases of intense market activity innovation clusters compete with the ecosystem in which they operate. (European Commission 2019.)

The respondents of the study on mapping Internet of Things innovation clusters in Europe (2019) named the correct balancing of cooperation and competition within the cluster as one key challenge. The unwillingness to share ideas or knowledge and an individualistic approach to the market is considered disruptive for cluster development. The commitment of strategic members may be cautious when it comes to participating in clusters and sharing internal knowledge. Large companies may be regarded as rigid and to lack the flexibility to adapt to common cluster processes and to efficiently cooperate with SMEs. Start-ups may perceive the pace of implementation and development as well as cluster dynamics and processes very slow, and these may threaten their economic sustainability. Exceedingly high transaction costs may hinder networking within the cluster. Data protection and privacy issues are notable obstacles for intermediate and final user acceptance of the data-intensive IoT activity, users must be able to trust the IoT systems developed. Case study participants have confirmed that insecurity is still very high in certain situations related to regulatory issues, data security issues and legal framework, these can have a negative effect to IoT related activities and the attitude of users.

The challenges clusters face may become success factors once they are effectively tackled through processes, which may become good practices. These challenges concern all the phases of a cluster's life cycle (i.e. launch, initiation, development and sustainability). Clusters are successful if they create value for their stakeholders and if they are engaged in the constant monitoring and adjustment of their strategy and operations. Clusters need to support the technology dialogue, solution finding, and problem solving and deploy effective marketing and internationalization initiatives for their members, running incoming and outgoing missions to explore new market opportunities. (European Commission 2019.)

One of the key aspects of IoT development within innovation cluster is creating a critical mass of research activities and avoiding duplication and the associated inefficiencies. The most successful innovation clusters engage their members in the regular revision, adjustment and renewal of the cluster strategy and economic and operational positioning of the cluster. The processes of the cluster and the involvement of cluster members need to be agreed upon, defined and formalised. Processes need to be agreed and optimised to fit the need of the innovation cluster, those of the cluster members, including SMEs, and they cannot constraint operations and innovation creativity. The entire surrounding ecosystem affecting the innovation cluster needs to be observed and monitored, the identification and assessment of external qualitative and quantitative strong and weak signals are key activities for the cluster's strategic monitoring. (European Commission 2019.)

2.2.6 University-Business collaboration

Advanced regions often have similar education systems, ranging from basic to tertiary education. Leading innovation clusters require highly educated and highly specialised human capital, but many have stated the need for a qualified training of students as finding qualified students is holding back the growth of many clusters. (Lindqvist & Sölvell 2011.) The information and communications technology (ICT) sector is especially dependent on highly educated workforce, making ICT research related to the development of high levels of education of special importance. Through closer cross-border cooperation between high education institutions and the ICT sector it is possible to build up a critical mass and supply a vast scientific base and highly educated labour force for the ICT sector within the EU. (Sundbo, Gallina, Serin & Davis 2006. 80-83.)

Mobility is a critical matter in European collaboration between higher education and the business community, because it provides the transfer of knowledge according to the needs of industry and prepares the graduates of higher education institutions with first-hand experience for the labor market. Cooperation between higher education and industries to promote the value of mobility is therefore necessary for the development of industries and higher education, and even the whole society. Partnership between higher education institutions and companies is in a crucial role to ensure high competitiveness of industry in any sector or region. Collaboration between universities and business is beneficial for both parties, universities benefit from complementing their own academic research and from commercialization of research results. Benefits to business include increased access to new higher-level research and discoveries. (Wagner et al 2012.)

The results of a study conducted by European Commission (2018c) showed that, given the right circumstances, university-business cooperation may be highly beneficial for all parties involved. The benefits of partnering or working with higher education institutions (HEIs) offer companies a source of future-oriented innovation and talent development that may build a competitive advantage. There is also evidence that higher education institutions are increasingly seen as a source of talent and entrepreneurship and they have a leading role in regional development. Still most academics and businesses do not engage in university-business cooperation, as opposed to a vast majority of higher education institutions. This limited collaboration is hindering the labor market relevance of the study programmes, the employability of graduates and the impact of research.

Through university-business cooperation HEIs may better align curricula and the skills of graduates with the need of the labor market. This will improve the employment pathways for students and support lifelong learning programmes that create high-tech new companies and entrepreneurial talent for the market. Collaboration with business offers higher education institutions insights, opportunities, data for high quality research and the ability to bring research to practice together to create impact. Companies gain benefits from innovation with a long-term horizon as well as short-term problem solving. (European Commission 2018c.)

All stakeholders are still facing barriers to university-business cooperation, as demonstrated in Figure 12. HEI managers and businesses agree that the lack of funding and resources is a considerable barrier to cooperation. Other obstacles include bureaucracy, the lack of time, cultural differences related to time management and differing motivations. (European Commission 2018c.)

HEI MANAGERS		BUSINESS COLLABORATING WITH HIGHER EDUCATION	
Limited resources of SMEs	7.5	Differing motivations between u niversities and our business	6.0
Lack of business funding for UBC	6.8	Lack of people with business knowledge within universities	6.0
Lack of government funding for UBC	6.7	Differing time horizons between universities and business	5.9
Lack of university funding for UBC	6.6	Lack of government funding for UBC	5.9
Insufficient work time allocated by the university for academics´ UBC activities	6.4	Bureaucracy related to UBC in universities	5.8
Frequent staff turnovers within the university or in our business	4.1	Frequent staff turnovers within the university or in our business	3.3

Figure 12. Barriers to University-Business Cooperation. Relevance of Motivators, Scale: 1 = not at all, 10 = to a high extent. (European Commission 2018c.)

Although it is important to remove the barriers preventing university-business cooperation, the development of the drivers of cooperation is even more important. The removal of obstacles does not necessarily trigger university-business cooperation, but collaborators will find a way to cooperate if there are enough drivers for cooperation. These drivers for cooperation include both motivators and facilitators. Based on the study conducted by European Commission the primary reason for HEIs to collaborate with businesses is to obtain funding and financial resources, followed by research drivers. The primary motivators for businesses to collaborate with HEIs are driven by organizational resource development, such as access to new technologies and knowledge, they include research as well as obtaining funding and financial resources. The least important motivator for HEI managers was to address societal challenges and issues, for business managers the least important motivator was access to university facilities. These drivers and their importance are demonstrated in Figure 13. (European Commission 2018c.)

HEI MANAGERS		BUSINESS COLLABORATING WITH HIGHER EDUCATION	
Obtain funding / financial resources	8.2	Get access to new technologies and knowledge	7.6
Improve graduate employability	8.1	Improve our innovation capacity	7.6
Use the university´s research in practice	8.1	Access new discoveries at an early stage	7.1
Improve the reputation of the university	7.9	Obtain funding / financial resources	7.0
Positively impact society	7.9	Provides access to better qualified graduates	6.8
Address societal challenges and issues	7.7	Access university facilities	5.4

Figure 13. Motivators for University-Business Cooperation. Relevance of Motivators, Scale: 1 = not at all, 10 = to a high extent. (European Commission 2018c)

The study (2018c) showed that relationships are perceived as the greatest facilitator of university-business cooperation for both HEI and business managers. Collaboration is enabled and eased by relationship-related facilitators, such as mutual trust, mutual commitment and a shared goal as well as funding. The short geographical distance between the two organisations is considered the least important facilitator for HEI and business managers both. The different facilitators of university-business cooperation are demonstrated in Figure 14.

HEI MANAGERS		BUSINESS COLLABORATING WITH HIGHER EDUCATION	
Existence of mutual trust	8.3	Existence of mutual trust	8.0
Existence of a shared goal	8.1	Existence of a shared goal	7.8
Existence of funding to undertake the cooperation	8.0	Existence of mutual commitment	7.7
Existence of mutual commitment	8.0	Existence of funding to undertake the cooperation	7.7
Prior relation with the business partner	7.7	Prior relation with the university partner	7.0
Short geographical distance between the two organisations	6.4	Short geographical distance between the two organisations	5.7

Figure 14. Facilitators for University-Business Cooperation. Relevance of Motivators, Scale: 1 = not at all, 10 = to a high extent. (European Commission 2018c)

2.2.7 IoT Innovation Clusters in Europe

There is a generalized trend of ICT companies and research organizations to participate in innovation clusters, which are actively developing innovative IoT products and solutions. They create new applications, cross-border value chains and ecosystems to take advantage of the opportunities offered by technology and the increasing mass of available data. A study on mapping Internet of Things innovation clusters in Europe by the European Commission identified 389 IoT innovation clusters in the EU with 12,023 member companies. The study assumes that the number of EU IoT innovation clusters and their member companies is even greater, but the numbers provide a good basis to portrait the European IoT innovation cluster landscape. Of the respondents, half were companies (597), followed by higher education institutions (134) and research and technology organisations (153). The fundamental drivers of the institution of European IoT innovation clusters and the reason for their establishment are response to industrial and sectorial crises in specific geographical areas or crises of large enterprises usually driven by Public Private Partnerships, EU supported Public Private Partnerships targeting specific issues such as the Future Internet, clusters initiated on the initiative of administrations of the different countries or regions and the introduction of the Industry 4.0. (European Commission 2019.)

The study on mapping Internet of Things innovation clusters in Europe (2019) confirms that the prevailing mode of cooperation between IoT cluster members is a horizontal one which means that the links are established on an opportunity-driven, ad hoc base and do not build on, or develop any hierarchical structures between their collaborative members. This suggests that membership in IoT innovation clusters is voluntary and based on specific market opportunities and technological opportunities. The most important players in investigated innovation clusters are system integrators, software developers and component developers and producers, with the other members playing minor supplementary roles. It also confirms that innovation clusters are mainly driven and sustained by market and technology-oriented business-players more than anyone else.

The most important application domain of EU IoT innovation cluster members is Smart Industry (25,2% of application domains in the organization offering), strengthened by the Industry 4.0 policy. The second most important domain is Smart Cities (20,9%), followed by Smart Living (16,9%), Smart Energy (15,9%) and Smart Environment (10,2%). These application domains are demonstrated in Figure 15. (European Commission 2019.)

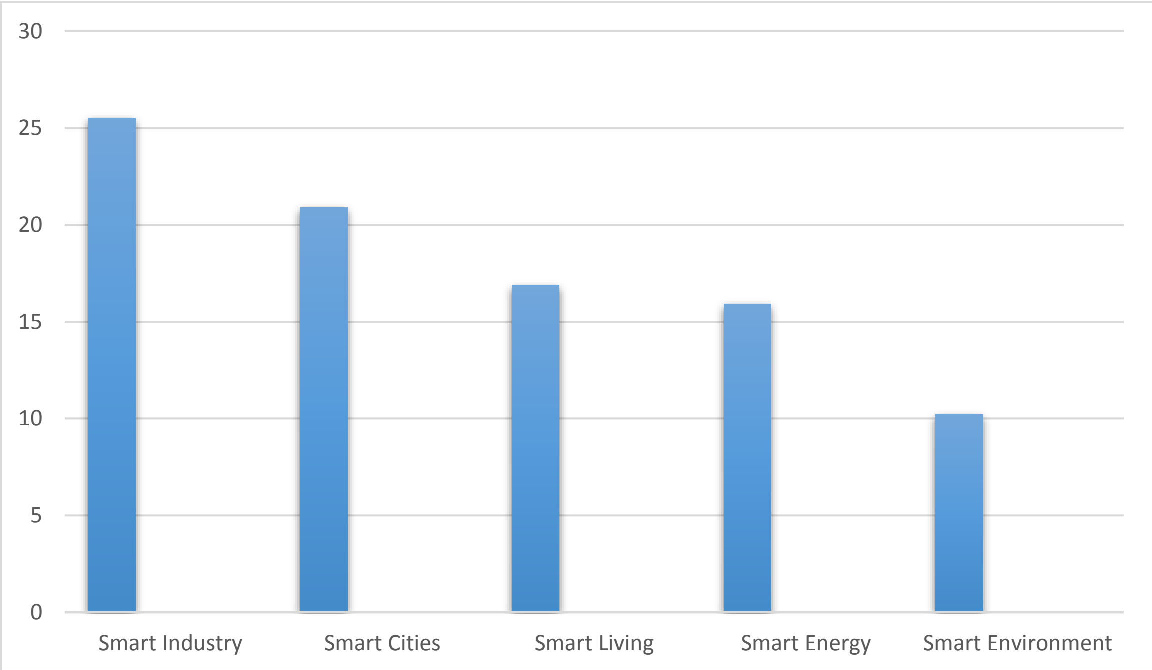

Figure 15. European IoT Innovation Clusters by Domain (European Commission 2019.)

2.3 Conceptual Framework

In this section the theoretical framework and main concepts of the literature review are combined to see how they have guided the data collection and analysis and how they are linked to the objective of this study and the research questions. The aim of this study is to define the factors and impediments of success and sustainability of University-Business innovation clusters, and to research the different funding and financing options and models for the IoT Rapid-Proto Labs project.

In the literature review, the basic concepts of University-Business innovation clusters were discussed, as were the drivers and obstacles for the success and sustainability of them. The conceptual framework of this study, illustrated in Figure 16, was formed based on literature review. The first and second part of the conceptual framework include the drivers of success and sustainability of University-Business innovation clusters. The sustainability of University-Business innovation clusters is endorsed by supportive management of the cooperation, strong and trusting relationships and offering the members a competitive advantage they could not obtain on their own. The success of University-Business innovation clusters is based on a clear and shared vision for the collaboration, the willingness of the members and stakeholders to share their knowledge and skills, and the added-value the innovation cluster offers its stakeholders. The third part of the conceptual framework is funding, which consists of public and private funding sources. It is important to notice, that all the three factors are related to each other. The factors and practices that support the success of University-Business innovation clusters, also support their sustainability. When a University-Business innovation clusters has proof of success and sustainability, it might make it easier to attract additional sources of funding and financing. The success and funding of the innovation cluster support its sustainability as well as each other.

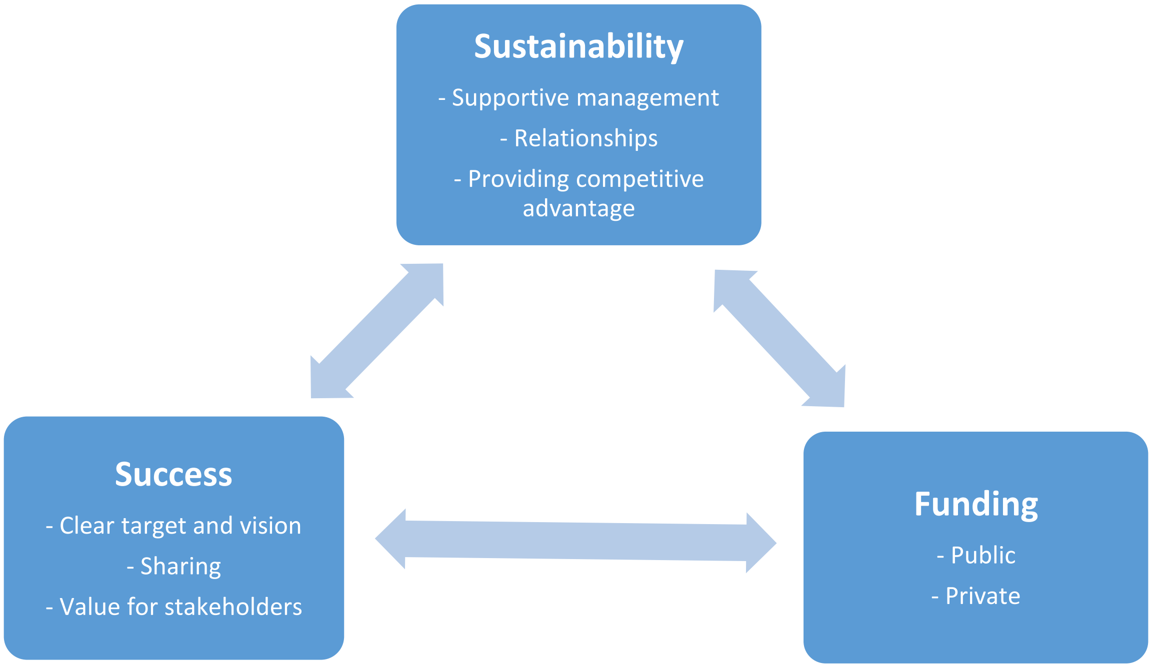

Figure 16. Conceptual framework

For this research, the interview questions presented in Appendix 1 were formed based on the conceptual framework described above. The first and second part of the interview questions addressed the factors contributing to the success and sustainability of University-Business innovation clusters and the interviewees' personal experiences and reflections on them. Different funding models for University-Business innovation clusters were also described in the literature review and the third set of interview questions was related to this theme.

To briefly summarize this section, the main topics that were discussed were the concept of IoT and the opportunities and challenged this emerging technology presents. The European IoT market and the growth possibilities were also discussed. The theory of University-Business Innovation Clusters and Open Innovation were described and the factors that influence the success and sustainability of University-Business Innovation Clusters and their different funding models were reviewed. Finally, the conceptual framework for this study was introduced.

3 Research Methodology

In this chapter the research methodology for this study is described. The research philosophy, research approach and strategies are discussed, and the data collection and analysis are explained.

The research 'onion' described by Saunders et al. (2016, pp. 122-124) and presented in Figure 17 depicts the issues determining the selection of data collection techniques and analysis processes. When coming to this central point, the researcher must explain why they have made such choices so others can see that the research should be taken seriously. The important outer layers must be understood and explained as well. The onions outer two layers include research philosophy and approach to theory development. Other layers include methodological choice, strategy, time horizon and techniques and procedures including data collection and data analysis.

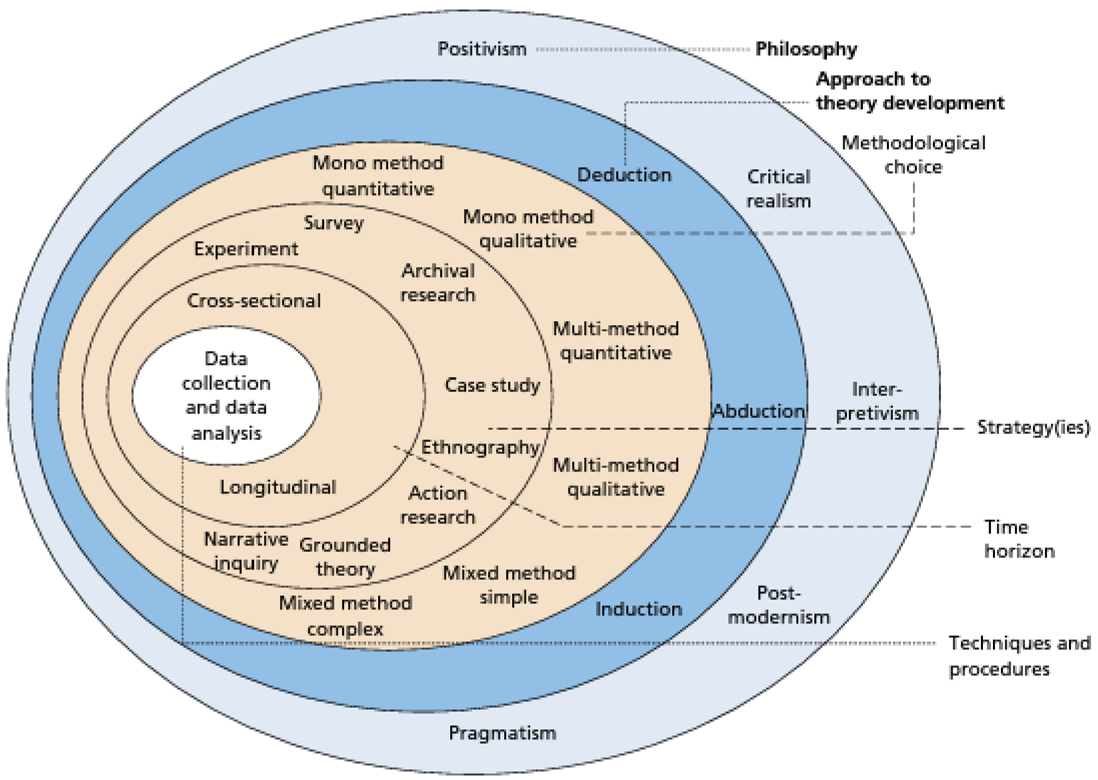

Figure 17. The Research 'Onion' (Saunders et al. 2016, pp. 124)

Qualitative research is usually associated with an interpretive philosophy as researchers use qualitative data collection techniques including interviews and questionnaires to make sense of the subjective and socially constructed meanings expressed about the phenomenon that is being studied. Data collection is non-standardised so research questions and procedures may alter and emerge during a research process. The success of the researcher's role depends on gaining physical access to participants, building compatibility and displaying sensitivity to obtain cognitive access to their data. (Saunders et al. 2016, pp. 162 – 178.)

Ontology

The researcher's view of the nature of reality is referred to as ontology. The researcher must understand what assumptions are made about the world around through the knowledge of one's own values and beliefs as they will determine the actions the researcher takes in the study as well as the approach to data collecting. (Saunders et al. 2016, 127.) For the research philosophy in ontology in this study I have selected subjectivism. The reason for this selection is that I, as a researcher, have a subjective perspective on the topic and I understand that the interviewees are influenced by the perceptions and actions of social actors and will attach their own meanings to their answers. This study will not produce any objective truth on the research topic.

Epistemology

Epistemology relates to what the researcher considers as acceptable knowledge within the field of the study. Basically, it is the knowledge which the researcher considers to be valuable and important enough to be studied in the research. (Saunders et al. 2016, 127.) For the research philosophy in epistemology I have chosen interpretivism. In interpretivism the researcher needs to be empathetic and look at the world from the interviewees' point of view. This research was conducted with semi-structured interviews which allowed flexibility for interpretation of the information gained, as I was able to ask probing questions and build on the interviewees' responses.

Axiology

Axiology relates to the values of the researcher and how they are indicated in the research project. Axiology also includes how these values affect the result of the study. (Saunders et al. 2016, 128.) My personal values are visible throughout the research. The choices I have made as a researcher are visible throughout the research project, from designing the study to the ways of conducting it. For this study, I have considered my own values throughout the progress of the research and was involved in the research itself as an active participant and an observer. I have been as objective as possible which indicates that this research is value bound.

3.1 Research Approach

The purpose of my study was to learn more about a specific topic and issue by exploring the landscape of the IoT industry and the success and sustainability of Business-University innovation clusters and their funding. I aimed to know the status quo in all its facets and to gain a deep insight into the field of the study so I could give recommendations for the future for the sponsor project. I did not enter a cyclical approach of evaluating and revisiting the suggested options and changes, nor did I participate in the decision-making or in implementing the suggested changes. Therefore, my chosen research approach was extensive case study.

In case study research the construction of a case or cases is essential. The research questions must always aim at understanding and solving the case. The objective of case study is to examine the case in respect to its historical, economic, technological, social and cultural context. Although case research has a qualitative spirit, quantitative data can also be used. For case study research empirical data may be collected from either one or several sources such as statistics, articles, web pages, interviews, surveys and observations. Case studies are typically considered more valid, credible, diverse and valuable if they are based on several sources of empirical data. One of the most important skills of a case study researcher is defining appropriate research questions. This is typically done in dialogue with empirical data, research questions need to be specified during the research process. (Eriksson & Kovalainen 2011, 116-125.)

There are two types of case study: intensive case study and extensive case study. Intensive case study aims to understand a singular case from the inside by providing a deep, holistic and contextualized description of the case. The aim of extensive case study is to elaborate and test theories, and to produce generalizable theoretical constructs by comparing several cases. Extensive case study research aims to map dominant patterns, mechanisms and characteristic within the chosen context that can be used to develop, elaborate or test a theory. Cases are used as instruments to investigate specific business-related phenomena and to develop theoretical hypothesis that could be tested and generalized to other business contexts or to theory. (Eriksson & Kovalainen 2011, 116-125.)

3.2 Data Collection

Data collection enables the researcher to answer stated research questions, test hypotheses and evaluate outcomes. In the data collection process the researcher gathers and measures knowledge on variables of interest, in an established and systematic manner.

The aim is to capture quality evidence that is used as a basis for rich data analysis enabling the researcher to build convincing and credible answers to the research questions. Data is organized into two broad categories: qualitative and quantitative data. Qualitative data are often non-numerical and descriptive or nominal in nature, and in the form of words and sentences. Qualitative approaches aim to answer questions such as 'why' and 'how' and often use unstructured data collection methods to thoroughly explore the research topic. (Kabir 2016.)

There are numerous ways to classify data, a typical classification is based upon who collected the data. Primary data refers to data that has been collected from first-hand experience and has not been published yet. Primary data is considered more reliable, credible and objective. Sources of primary data include experiments, surveys, questionnaires, interviews and observations. Secondary data refers to data that has been collected from a source that has already been published in any form. Literature review is always based on secondary data. Secondary data is collected by someone else other than the researcher and for some other purpose. However, secondary data is crucial to any research as it is impossible to conduct a new survey that can sufficiently capture past change and development. A research can be conducted without the use of secondary data, but a research that is based solely on secondary data is considered less credible as the data has already been manipulated by someone else than the researcher. Sources of secondary data include books, newspapers, articles and databases. (Kabir 2016.)

3.2.1 Interviews

When using in-depth qualitative interviewing, the researcher talks with individuals who have knowledge of or experience with the topic of interest. The aim is to thoroughly investigate the experiences, motives and opinions of the interviewees and to see the topic from their perspectives. Qualitative interviewing helps reconstruct events the researcher has never experienced, create portraits of complicated processes, challenge long-held assumptions and capture change. (Rubin & Rubin 2012, 3-4.)

Interviews may be conducted by a variety of formats including face-to-face, telephone, video conferencing and online interviews. Face-to-face interviews are often viewed as the preferred approach as they allow the interviewer to interact with the interviewees and note their full response including the tone of voice, manner and body language. As conducting interviews is time-consuming, they are generally only appropriate for small samples. The greatest strength of interviews is the fact that very large amounts of data can be gathered during each interview and the level of details and quality of material can be considerable.

There are three main types of interview: unstructured interviews, semi-structured interviews and structured interviews. (Burton et al. 2014, 132 - 135.) For my study I chose to use semi-structured interviews.

In semi-structured interviews the interviewer uses a set of predefined questions under main headings, the interviews also allow some extent of latitude within the discussion. They take place as a scheduled, often extended conversation between the researcher and the interviewee. In semi-structured interviews the researcher has a specific topic to learn about, a limited number of prepared questions and plans to ask follow-up questions. The interviewee is encouraged to answer at length and at vivid detail, still keeping the main focus on the planned topics that are related to the research. Qualitative interviews are based on main questions, follow-up questions, and probes that together produce rich data that is related to and corresponding to the research questions and topics. Main questions start the discussion about each separate section of the research question. Follow-up questions are used to gather detailed information about the themes, concepts or events that the interviewee mentions. Probe questions help the researcher to keep the conversation on the topic, ask for examples or clarification and signal the desired level of depth. (Rubin & Rubin 2012, 31, 116.) The interview questions used for this research are presented in Appendix 1. They are based on the theoretical and conceptual frameworks introduced earlier in chapter 2. As presented in Figure 16, the conceptual framework of this study consists of three interrelated parts, the drivers of success and sustainability of University-Business innovation clusters and funding, which includes public and private funding sources.

3.3 Research Process

The research work was conducted between May 2019 and May 2020. The idea and opportunity to conduct the study was represented by the IoT Rapid-Proto Labs project. The initial briefing suggested an industry analysis mapping out the emerging IoT development structure in Europe, but the focus shifted to studying University-Business innovation clusters and their success and sustainability drivers and financing during the research process. For research questions 1, 2 and 3 data were collected through exploring available and relevant literature for the topic and study. Based on the data collected the conceptual framework for this study was constructed and a semi-structured interview questionnaire was formed. Altogether 7 experts were interviewed during March and April 2020 to gain deeper insight of the research topics.

The strength of interviews is that they allow flexibility, the interviewer can repeat the question or to rephrase it if needed, correct possible misunderstandings, change the order of the questions, and have a discussion with the interviewee. Semi-structured interviews aim to find meaningful answers and insights to the objectives of the research and the research questions. (Tuomi & Sarajärvi 2018.) The difficulty in the data collection phase for the research was that all interviewees were located physically in different cities and countries making it impossible to conduct the interviews face-to-face. The researcher had not met or discussed with any of the interviewees before, which might have affected the response rate of the interview invites. Due to geographical distance the interviews were arranged in Microsoft Teams live meeting platform, except for one that was conducted over telephone due to technical difficulties with the platform. During one of the interviews the interviewee shared slide shows introducing the innovation cluster and its members which gave very good insights on the topic.

3.3.1 Case Interviews

Initially 13 interview invitations were sent in the beginning of March 2020 by email to innovation clusters identified in the Study on mapping Internet of Things innovation clusters in Europe (European Commission 2019) that had higher education institutions as members and activity in the same geographical area as IoT Rapid-Proto Labs (Finland, Germany, Italy, The Netherlands). The interview questions were attached to the invitation emails. Because interviews are not seen as quizzes but aimed to gain a deeper understanding of a topic, it is recommended to provide the interviewees background for the interview well in advance, the interview questions can also be provided beforehand (Tuomi & Sarajärvi 2018). For recipients who hadn't replied to the first invitation, a reminder was sent 1,5 weeks after the first invitation. From these 13 interview invitations 6 interviews were arranged. To broaden the data collection, additional 5 interview invitations were sent in the end of March 2020 to innovation clusters identified in the same European Commission's study that had activity in other European countries. From these 5 interview invitations one interview was arranged.

The semi-structured interviews had both structured and unstructured elements of interviewing, using a fixed set of sequential questions but also additional questions were asked depending on the situation. The duration of the interviews varied from 25 minutes to 95 minutes, the average duration was 44 minutes. The interviews also included some free comments at the end. Three of the interviews were conducted in Finnish and four in English. All the interviews were recorded and then transcribed soon after the interview. The interviews conducted in Finnish were first transcribed and then the transcriptions were translated to English.

All the interviewees had many years of previous experience in University-Business cooperation in addition to the connections to the innovation clusters the interviews were addressing. Some were or had been working in universities, some in operational business positions and some in public organizations and funding institutions. Because the interviews were conducted anonymously, the innovation clusters and the interviewees cannot be revealed in this report. They are however briefly described below to understand why they are relevant to the study.

Innovation cluster 1

Innovation cluster 1 is an IoT alliance and development program that delivers IoT solutions that are integrated to the customer's existing processes, tools and platforms. The cluster includes over 150 companies, several research and business development partners and cooperation both on national and international level. The interviewee was the Alliance Leader of the innovation cluster.

Innovation cluster 2

Innovation cluster 2 is a company-driven cluster that promotes co-creation activities capitalizing on sustainable digitalization of companies. It offers an open platform for sharing experiences, identifying new business opportunities and future trends, and exploring testing and piloting activities. The innovation cluster has nearly 200 members including large and small industrial enterprises, individual entrepreneurs, academics, and government organizations. The interviewee was the Program Manager of the innovation cluster.

Innovation cluster 3

Innovation cluster 3 is a Smart City innovation company of a European metropolitan city. It co-creates urban products and services together with residents, companies, universities and other public sector organizations. It has a European-wide collaboration network, members of the innovation cluster include for instance higher education institutions, IT companies, funding institutions and public organizations and ministries. The interviewee was a member of the steering group of the company.

Innovation cluster 4

Innovation cluster 4 is a collaboration that creates open innovation ecosystems by providing a platform that enables companies to easily create new IoT systems and to rapidly harness available information with minimal investment. The innovation cluster has over 50 members including market leading industrial organisations, companies, research organisations and public authorities in major European cities. The interviewee was the WP Leader of the innovation cluster.

Innovation cluster 5

Innovation cluster 5 offers companies easy access to new business development and pilot manufacturing resources related to printed intelligence components, systems and products, including pilot production and early market trials. The innovation cluster has over 300 experts, and a wide global reach with its international member companies and partners. The interviewee was the Director of the innovation cluster.

Innovation cluster 6

Innovation cluster 6 is a European business network for companies creating and applying electronic solutions and digital technology. Its areas of expertise include Smart Health, Smart Cities, Smart Systems, Smart Flexible Electronics and Smart Industry. The innovation cluster has over 100 members include universities, research institutes, small Startups, SMEs and large international groups. The interviewee was the Industry Program Manager of the innovation cluster.

Innovation cluster 7

Innovation cluster 7 is an international Smart Health collaboration that aims to strengthen the research and development capacities in the medicine and healthcare sector, develop innovative ideas into products and support innovations and technological improvement within the industry. The innovation cluster has over 20 members including universities, SMEs and large international companies. The interviewee was the Director of the innovation cluster.

3.4 Data Analysis

Thematic analysis is a method for systematic identification, organization and providing patterns of meanings and experiences from data (Braun & Clarke 2012). Data analysis of qualitative research begins with the researcher deciding what in the data is interesting and labelling from the data the things that are related to these interests and omitting everything else. As qualitative research always unveils several interesting topics the researcher has not been expecting to find out, it is tempting to include all findings in the study. However, topics that are not relevant to the research objectives and questions must be left to following studies. (Tuomi & Sarajärvi 2018.)

Data analysis of qualitative research is often divided into inductive and deductive analysis. In inductive analysis new theories are formed based on the data, in deductive analysis data is gathered to test a theory. A third approach to data analysis is abductive, where the formation of a theory is possible only if observations are based on a leading thought.

(Tuomi and Sarajärvi 2018.) The data analysis method used in this study is abductive, data analysis was focused on occurring themes and comparing interviews and cases to each other. In abductive data analysis the analysis is not entirely based on theory, but linkages to it are visible. The theory is referred to in order to find explanations and verifications to the observations from the data. The data analysis is often guided by the preconceptions of the researcher and the literary review conducted for the study that steer the researcher to concentrate on important themes. For this research the research questions and interview questions were formulated using existing theories. Data was studied to form rules and patterns that could confirm the theoretic framework and develop a theory that could explain the found patterns.

The first step of data analysis of interviews for this study was to prepare transcripts of full and accurate word-for-word written rendition of the interview questions and answers immediately after the interviews. In this study the data was coded using ATLAS.ti software instead of manual coding and labelling. The transcripts of the interviews were imported to the program and coded according to research question topics. Although the interviews were semi-constructed, the interview questions remained same throughout all interviews. After coding the entries, the data was categorized, summarized and analysed. After picking up from the most frequently occurring themes most important for the objectives of this study and most relevant according to theoretical background, the number of thematic categories was reduced by looking at commonalities, grouping similar themes together to broader categories and removing redundancies. A set of related concepts and themes that could answer the research questions were identified and the theory was formed based on themes introduced in the conceptual framework of this study.

3.4.1 Accuracy and Credibility

A notable strength of qualitative interviewing is that it produces remarkably reliable results because every conclusion is firmly linked to solid evidence that is embedded in a context. The researcher must report in an accurate and transparent manner what the interviewees have told them and how they have made the analysis. The interviewees must have knowledge on the research topic and the interview questions must be restricted to what they know in first hand. For ensuring the accuracy of the research, interviews should be recorded and transcribed word to word immediately after the interview. The credibility of the research is achieved in part by showing that the researcher has talked with people who are informed about the research topic. The researcher must also ensure that the interviewees are talking from their own experience and accurately remember the events or processes they are asked about. Credibility is also ensured by the carefulness the researcher has carried out the research. Findings need to be reported in a transparent manner which allows the readers to see the process whereby the data were collected and analysed. A transparent report allows the readers to assess the thoroughness of the research design as well as the conscientiousness, sensitivity and the biases of the researcher. (Rubin & Rubin 2012, 64-68.)

In this chapter, the research methodology was discussed, and the research approach was explained. The case innovation clusters used for the interviews were presented. The methods, strategy and techniques for data collection and data analysis were also explained.

4 Presentation of the Findings

In this chapter, the general findings for each research question is summarized. The objective of this study is to identify sources of support for the IoT Rapid-Proto Labs project to enable the success and sustainability of the project. This is achieved by studying and explaining the actors of University-Business innovation clusters and the relationships between them, defining the factors and impediments to success and sustainability and researching the different funding and financing options and models for them.

4.1 The Success Factors in University-Business Innovation Clusters

The first set of interview questions was related to the success factors in University-Business innovation clusters and addressed the interviewees' personal experiences of University-Business cooperation. Obstacles and impediments to success were also researched.

4.1.1 Factors Facilitating Success

The most successful innovation clusters the interviewees identified had created products and services that had proven to be commercially profitable, answered market needs and requests and created something unique and technologically advanced.

The importance of the shared research and development of innovation clusters was emphasized in all interviews. When researchers and companies are working together towards shared targets and visions, the cooperation can be truly complimentary. Universities are in forefront in development of technology but not driven by market demand or commercialization of innovations, whereas companies are more practically focused and driven by customer needs and market capitalization. The new products and services developed by innovation clusters combine the specific knowledge and expertise each cluster member has and are therefore more advanced and complex than what any of the members could have developed on their own. An innovation cluster can establish the best results when it has a comprehensive representation of different actors of an industry including higher education institutions, small and large companies, funding institutions and public organizations.

Main key factors facilitating the success of innovation clusters were having a clear target and vision and ensuring that all members of the innovation cluster are committed to them. This ensures that the cooperation is focused towards a common goal and that the members have trust in one another. As all members of innovation clusters have their own goals and interests of focus, individual needs need to be acknowledged. The vision and the organizational structure of an innovation cluster need to be flexible and agile so they can adopt to changes in the market or new technological innovations. If the members of an innovation cluster share common history and have collaborated before, it eases the cooperation as trust and solidarity have already been established.

Innovation clusters need to create value chains where knowledge is created in universities and transferred to companies and other cluster members, facilitating this knowledge value chain was defined as the most important task for innovation clusters by one interviewee.

4.1.2 Impediments to Success

The members of an innovation cluster may sometimes have differencing objectives and reasons for cooperation, which may cause conflicting interests. The initial innovation cluster consortiums can change over time as some members may leave the innovation cluster and some new members may join. This can cause changes in the objectives of the innovation cluster and cause trust issues between the members. Public funding may not be easily adaptable to changes as financing cannot be transferred from an old member of the innovation cluster to a new member.

Companies are often faced with strict time-to-market and have limited amount of time for research and collaboration. Higher education institutions are not often used to working with such strict time schedules, which may cause difficulties in the collaboration. Sometimes the research and projects have taken more time that originally estimated, productization can also be more time consuming as initially estimated and time-to-market can also prolong.

Sometimes research done by higher education institutions was seen as too specific or too basic, and not easily translatable to the practical needs of companies and industry. Sometimes the need for the researched technology has been too ahead of time, and the demand for it from the industry has come years after the development. Even though the goals of an innovation cluster may be reached, and new technology developed, the new products and services might not be commercially scalable and offer new business possibilities for the members of the innovation cluster.

4.1.3 Added Value of University-Business Collaboration

All interviewees highlighted the networks and connections innovation clusters provide their members as one of the most important added value of the cooperation. Companies participating in innovation clusters gain new knowledge and connections and can better answer the questions and demands of their customers. The members of innovation clusters gain knowledge of the market and industry as they see what technology is researched and focused on and by who. They gain information on trending topics and future needs of the market.

Especially SME's and Start-ups do not usually have direct contact to research institutions nor knowledge or experience in different funding and financial instruments and application processes. They might not have the time to make project plans or financing plans. As one company cannot often do these themselves, cluster membership offers them research resources, management facilitation, project management and project design. Innovation cluster organizations offer their members professional abilities to draw up and manage financing and funding applications. Especially the application process for EU funding has been found time-consuming and cumbersome.

Higher education institutions can establish direct links towards companies and industry, provide them new knowledge and get links to end-customers of the knowledge they produce to ensure that their research is relevant and that they have a voice in the community and industry. Cooperation helps students gain relevant skills and connections through internship and thesis positions and enhances their employability. Students and graduates of higher education institutions gain contacts to companies so they can pursue their own personal professional careers. Collaboration with companies and industry members of innovation clusters ensures that they have relevant skills for their future careers and the needs of labour market. For the staff of higher education institutions collaboration offers means to maintain and develop their professional skills, offers practical research experience and provides material and references for their personal research activities. Especially universities of applied science have a strong connection to business and working life. External research and development projects represent a significant portion of funding for higher educational institutions and provide long-term partnerships.

4.2 The Sustainability of University-Business Innovation Clusters

The second set of interview questions was related to the sustainability of University-Business innovation clusters and aimed to discover the factors and practices that support it as well as obstacles and impediments to it. The interviews also explored the factors and practices that enable a University-Business innovation clusters to move from the early initiation and evaluation phase towards a sustainable collaboration model.

4.2.1 Factors Supporting Sustainability

The interviewees unanimously agreed that the research and development made in innovation clusters needs to be relevant to today's market and industry needs. The goals and scope of the activities and projects must be specific and focused, and they must be developed together. Also, the vision and goals of the innovation cluster need to consider the needs and aims of academia as well as companies participating in the cooperation, individual objectives and aspirations need to be respected. Members need to trust each other, working practices and responsibilities must be agreed upon as well as intellectual property rights. Innovation clusters must offer a "win-win" situation for all, each member must gain something from the collaboration they could not have gained on their own and also offer other members unique knowledge, skills or resources they lack.

Higher education institutions had been found to be truly committed to the cooperation once they become members of an innovation cluster. Many have joined the steering groups of the innovation clusters. Higher education institutions appreciate the chance to participate in the decision making and all decisions need to be approved by academia.

Ensuring that the innovation cluster has some industrial services (business to business) as well was also considered crucial to the long-term sustainability of the innovation cluster. Consortium members had been found to appreciate organized trainings, seminars and workshops where they get an opportunity to share the knowledge they have been working on to other members of industry, gain information on new technology and trends, and have the opportunity to get in touch with new contacts and partners.

When membership in the innovation cluster is renewed yearly, it ensures that the members are still committed the to the cooperation and shared goals, and if they are no longer interested in the membership they can leave. This ensures that all members are active in the collaboration and each member is giving as well as receiving benefits from it.

4.2.2 Moving from Initiation Towards a Sustainable Collaboration

One of the main factors the interviewees mentioned is that the collaboration must offer some advantage for every member of the innovation cluster. These advantages include access to research and funding, support from stakeholders, specialized skills and knowledge and new business opportunities. The concept of open innovation was brought up in many interviews, the members of the innovation cluster must openly share their development and achievements with others and not try to take possession of the results of teamwork by themselves. The members of the innovation cluster must meet regularly to discuss what they have been developing and researching to keep everyone up-to-date and to collectively decide what will be done next.

The importance of open discussion, close relationships between the members, mutual trust and good management processes were widely emphasized and that there are enough resources for management. Management of the innovation cluster needs to be clear, roles, responsibilities and goals need to be clearly defined. Intellectual property rights need to be decided upon, in many innovation clusters it had been decided that the ownership of the intellectual property is for the designers of it, but other members could freely utilise it. Strategic decisions need to consider the advantage for both academia and industry partners, as they often have differing goals and needs.

If the innovation cluster receives public funding, the funding needs to be long-term, predictable and the basis for the funding need to be transparent. There had been difficulties with the continuity of public funding, where the first application for the funding for the innovation cluster had been approved but the subsequent application had been turned down with no rational justification. But alliance with regional and industry councils were recommended especially by interviewees from innovation clusters that had activities in Finland.

If one member leaves the innovation cluster, the cluster needs to have something additional to offer for the remaining cluster members for the lost benefit and connections.

4.2.3 Drivers for Sustainability

Transparent and clear communication, trust and openness in individual and collective relationships, and the willingness to share ideas and knowledge were mentioned as factors supporting innovation cluster sustainability. The goals and the direction of the collaboration must be clear and shared by all members. All cluster members must stay on top on what is needed and expected within the innovation cluster. The development and research of the innovation cluster must stay focused and interesting and membership of the cluster must be worth-while for all members. The importance of sharing the acknowledgement and praises when communicating about reached goals and accomplishments was also highlighted, all who have participated in the collaboration must be mentioned and credit cannot be appropriated.

The products and services innovation clusters develop must have market value and they must be relevant to market demand. This verifies the credibility and prominence of the innovation cluster. The creation of new value chains confirms sustainable collaboration with all stakeholders and customers after development projects are finished. Partnership with large global organizations attracts smaller companies and research institutions to the collaboration and eases obtaining financing and funding. Higher education institutions participating in innovation clusters must aim to make their curricula globally remarkable and competitive to ensure that their research and the skills of their students, graduates as well as staff is relevant to today's market needs.

Innovation clusters might explore the possibilities of broadening their product and service portfolio after the start-up phase when the innovation cluster becomes more mature and has already proof of concept. The innovation cluster must be able to adapt and renew its strategy if the markets change or if some member leaves the innovation cluster. New members must not be seen as threats but as possibilities, they can be attracted by open calls.

Innovation clusters can regularly contact local companies to discuss possible challenges and difficulties they have experienced in their business to seek business potential. Then these companies can be invited to participate in workshops and seminars organized by the innovation clusters to describe these situations to the members of the innovation cluster and the members can then compose and present solutions the innovation cluster has to offer.

4.2.4 Impediments and Obstacles to Sustainability

The responses unanimously stated the lack of funding as the biggest obstacle to the sustainability of innovation clusters. Application processes for public funding are time-consuming and complex. It was stated by many interviews that public funding organizations are not consistent, just or predictable in their decisions. This was seen to lead to smaller business-to-business projects that do not advance academic research or the development of industries and regional economics.

Overlapping objectives, unclear goals and disputes about intellectual property rights had caused friction within the innovation clusters. Some members had not been willing to share their knowledge and innovation to other members. A lack of trust and transparency between the members of the innovation clusters had also been experienced. Some members had not been willing to share their resources, knowledge or innovation. These issues could be corrected by ensuring sufficient trust and communications between the members and also by providing comprehensive reasoning for made decisions, for example why certain stakeholders were chosen to participate in a project while others were not. The formation of confidentiality takes a long time.

Some innovation clusters had had unrealistic expectations and inaccurate budgets, that could have been avoided by detailed and realistic planning. Sometimes the scope of the innovation cluster had been too broad and there had been too many members making the collaboration impossible to manage and steer.

The different organizational cultures of higher education institutions and companies have caused issues and difficulties in some innovation clusters. Higher education institutions and business are not on the same level of the knowledge value chain, as universities often do research and know more about emerging technologies before companies and sometimes these do not have any market value in the next following years. As universities and companies have different procedures, different decision processes and different organization models it may cause friction between cluster members when discussing about deadlines and responsibilities. The goal and vision of the collaboration must be therefore made clear and specific, membership in the innovation cluster must be beneficial for all members, and the roles of academia and business need to be in balance. Everyone needs to have a feeling that they both give and receive.

In the beginning the portfolio of the services offered by innovation clusters is limited, which might hinder their abilities to compete for projects. Seeking business opportunities from the market place was seen as time-consuming. Other impediments and obstacles to sustainability mentioned in the interviews included the costs of international promotion and marketing, the lack of international credibility, the lack of skills for international lobbying, complex policies of public organizations and distances even between European countries. Some had experienced that it was difficult to manage collaboration within the innovation cluster if it had two or more higher education institutions as members as the higher education institutions regarded each other as competitors.

4.3 Financing and Funding Sources for University-Business Innovation Clusters

The third set of interview questions was related to the financing and funding sources for University-Business innovation clusters. The role of public and private funding was researched as was ways of attracting additional financing and funding.

4.3.1 Funding Models

All of the innovation clusters included in the research had received public funding, and only one did not have membership fees. Channels for public funding included the European Union and its different development programmes (e.g. Horizon 2020), the FP7 funding programme of the European Commission, regional and industry financing institutions such as European Investment Fund, TEKES, Business Finland, Helsingin kaupungin innovaatiorahasto, and Regional Councils. The participation of higher education institutions was in many innovation clusters defined as subcontracting research and development as some public funding institutions accepted funding applications only from companies, not from academic institutions.

Membership fees were based on the type and size of the member organization and their level of engagement in the collaboration. The membership fee for Start-ups was smaller than for SME's, and SME's paid less than large international companies. Higher education institutions and research organizations had their individual membership fee as did supporting stakeholders and investors.

Some innovation clusters offered project work regularly, designing individualized solutions and products to specific needs of companies. Project commissions were charged based on the utility of the developed solution or product for the customer or by the workload of the research and development.

4.3.2 Public Funding

When asked about the importance of public funding for the success and sustainability of innovation clusters, all interviewees determined it critical. Without public funding the focus of innovation clusters would be more on individual business needs, advanced research, industrial and regional development would not be supported, and societies would not be able to benefit from the outcomes. Several larger research and development projects could not have been possible without public funding as Start-ups and SME's lack the resources to participate in such collaborations. For larger companies public funding is critical to ensure renewal and participation in research and development projects that are not core to their business strategy. This assists the European market to compete with Asia and Northern America. Public funding was also seen to allow flexibility and freedom in exploring and developing different service models and new technologies.

Public funding enables higher education institutions to participate in innovation clusters, which ensures that the research they do is relevant to today's market and that graduates have relevant knowledge and skills for the demand of labour market and business industry. With public funding innovation clusters were able to pay some basic activities of the cluster organizations, such as salaries to the employees and finance the administrative work, thus lowering membership fees.

The bureaucracy and complexity of the application processes for public funding was critiqued, the decisions were hoped to be more transparent and fair. Still as public funding for projects is unclassified, it allows all actors in an industry and region to keep track on trends and emerging technology, and see what others are developing and focusing on. As there is competition for public funding, it ensures that the projects are relevant to current market and industry needs.

Companies often reduce their research and development investments during economic uncertainties and crisis. Especially during such times public funding ensures the sustainability of innovation clusters and industrial and regional economic development.

4.3.3 Private Funding

Six of the seven innovation clusters included in this research collected membership fees. For some innovation clusters the share of membership fees of the total funding was larger, covering most of the collaboration activities. For some innovation clusters the percentage of the membership fees of the total funding was smaller, covering mainly administrative activities, newsletters and seminars.

Membership fees should not be an obstacle to participation in innovation clusters, they should reflect the size and type of the organizations, the levels of their activity in the collaboration and the aspirations for it. Membership fees were felt to contribute to the commitment of the members to the short-term and long-term goals of the cluster and support the sustainability of the collaboration as public funding was not always felt predictable and reliable.

Fairly high membership fees could ensure that the members of an innovation cluster can prioritize the cluster work and that they are actively participating in the collaboration and committed to the goals. It could be better for an innovation cluster to have less members with higher membership fees than more members with smaller membership fees. As few have much appreciation to things they receive for free, membership fees are the best means to establish commitment to the collaboration as membership will be decided on strategic management level of companies.

Some innovation clusters offered additional benefits for their members in return of their membership fees, such as newsletters, participation in workshops and seminars, and free use of piloting and production resources. Some innovation clusters used the membership fees to cover the management activities of the organization such as assisting with funding applications and project management.

Thee of the innovation clusters regularly participated in commission projects, charging companies for specialized research and development projects. Clients for these projects included larger enterprises that did not have an interest in long-term partnership and smaller companies that did not have time or resources to commit to innovation cluster membership. The project commissions were regarded as a convenient way to attract additional funding to the innovation clusters and offered the members new and interesting assignments. The interviewees that had experience from commission projects underlined that the scope of these projects must be small, so they are easily manageable and do not take away too much time and resources from the innovation cluster's main goals and vision. Schedules must also be carefully aligned to avoid afflictions in deadlines.

4.3.4 Attracting Additional Financing and Funding

Making sure that the projects the innovation clusters work upon are innovative and relevant was generally seen as the most effective way to attract additional funding. Membership fees, project commissions, co-creation financing, co-innovation financing and public funding (European and local) were also mentioned often. Other often mentioned means included constant communication towards industry and media, raising awareness and promoting the achievements the innovation clusters have made.

Creating networks was also encouraged, many interviewees stated that previous commission project customers had ordered more project work, attended seminars and participated in the innovation clusters. The formation of small IoT consortiums and export rings that could make joined offers to different European countries was also suggested. Innovation clusters could also expand their geographical area of operation.

Some innovation clusters were involved in research-to-business cooperation, trying to find new business model possibilities for their members behind arising topics and inquiries. Many contacted local companies to discover the challenges and needs they have encountered to find new business potential and invited them to workshops and seminars to hear about the expertise and resources the innovation cluster had to offer.

Higher education institutions need to communicate more effectively to companies the knowledge and resources they can provide (including test environments, laboratories, apprentice and thesis assignments) and the value collaboration with them could offer.

Channels for providing additional financing and funding that were mentioned in the interviews included:

- EU (Horizon 2020 Research and Innovation programme)
- Business Finland (funding of Finnish innovations, assisting of internationalization)
- Sitra (independent public funding organization, supervised by the Finnish Parliament)
- Helsingin kaupungin Innovaatiorahasto (public funding organization for projects aimed to strengthen the economic growth and innovation of Helsinki region)
- Helsinki-Uusimaa Regional Council (joint regional authority for the Helsinki-Uusimaa Region)
- Teknologiateollisuus (lobbying organization for Finnish technology industry companies)
- TEKES (currently merged with Business Finland)
- European Investment Fund (offers a wide range of financial intermediaries for European SME's)
- European Research Council (funding for research projects in Europe across all fields of science, scholarship and engineering)

4.4 Summary of the Findings

The findings of the research presented in this chapter are summarized in Table 2. The findings are categorized below each research question.

Table 2. Summary of findings

1. What are the success factors in University-Business Innovation Clusters? a. What are the specific success factors in European IoT University-Business Innovation Cluster?
• Research and development needs to be relevant and focused • Innovation cluster must have clear target and vision shared by all members • Members must be committed to the collaboration and trust in each other • The cluster organization must be flexible and agile to adopt to changes in the market or the cluster members
2. What factors contribute to sustainable University-Business Innovation Clusters? a. What factors support sustainable European IoT University-Business Innovation Clusters?
• Projects must be relevant to today's market and industry needs • Vision and goals need to consider all members of the innovation cluster • Mutual trust, commitment to the collaboration • Supportive management, working practices and responsibilities must be agreed upon • "Win-win" situation, benefits for every member • Open and frequent communication • Sharing ideas and knowledge, Intellectual property rights • Long-term and predictable funding
3. What are the financing and funding sources for University-Business Innovation Clusters? a. What are the specific financing and funding sources for European IoT University-Business Innovation Clusters?
• Public funding - EU - Regional financing institutions and councils - Industry financing institutions and councils • Private funding - Membership fees - Commission fees

The of the study on mapping Internet of Things innovation clusters in Europe (2019) named the correct balancing of cooperation and competition within the cluster as one key challenge together with unwillingness to share ideas or know-how. Drivers for success include agreement and management of the processes of the cluster and the involvement of cluster members. The results of the research confirm these factors and suggest that most impediments and obstacles can be solved by clear rules and commitment. The innovation cluster must be able to adapt to changes in the consortium, funding or market demand.

The study conducted by European Commission (2018c) showed that relationships are perceived as the greatest facilitator of university-business cooperation for both HEI and business managers. Drivers for sustainability of university-business collaboration include mutual trust, mutual commitment and shared goals as well as funding. The results of this research confirm these findings as sustainable innovation clusters rely heavily in personal relationships, trust, commitment and sharing of ideas and knowledge within the University-Business innovation cluster. Innovation clusters must create value for the members and other stakeholders. Funding needs to be long-term and its prerequisites need to be predictable and transparent.

According to Lindqvist and Sölvell (2011) most innovation clusters gradually shift from public to private funding including membership fees and consultancy fees as the cluster matures. Public funding is crucial for the sustainability of innovation clusters, but it should not be the only source of funding. From the seven established innovation clusters included in this research, six collected membership fees and three collected commission fees. This verifies the importance of several sources of funding, as dependence on a single source of funding can be a weakness for an innovation cluster organisation as they are more susceptible to changes in the funding situation. The membership fees and commission fees should reflect the size, type and role of the participating organization as fees that are too high could prevent collaboration.

5 Recommendations and Conclusions

The primary research question for this study was to identify the sources of support within the IoT industry available for the IoT Rapid-Proto Labs project after EU project funding ends in 2020. To reach this objective the study examined the factors and impediments to success and sustainability and the different funding and financing options and models for University-Business innovation clusters. In this chapter specific recommendations for the IoT Rapid-Proto Labs project based on the research findings, discussed in chapter 4, are presented. The implementation possibilities of the recommendations are also discussed.

5.1 Recommendations and Implementation of Suggestions

Below the recommendations for the IoT Rapid-Proto Labs project and implementation of these recommendations are grouped by research themes. The project is at quite an early stage and has not yet reached maturity and sustainability, but it has achieved outputs and effects by finished development projects of IoT solutions and products for Star-up and SME clients.

Specific key performance indicators (KPIs) for each research theme are suggested below. There needs to be a consistent and systematic monitoring model for the KPIs so the outputs, inputs, results and effects can be observed and developed. This model should also include implementation of systematic benchmarking.

5.1.1 Facilitating Success

The research and development of IoT Rapid-Proto Labs is already focused and relevant to today's market needs as the activity is based on assignments from SME's and Start-ups. The goals and vision of the project is to bring higher education institutions and businesses together to accelerate IoT product development, and to strengthen the multi-disciplinary skills, employability, and career prospects of students. This is achieved by the course curriculum, the research and development assignments that are based on real-life market needs and the collaboration between students, teachers, companies and partners.

The goals, management, and collaboration of IoT Rapid-Proto Labs need to consider the different objectives and aspirations of all members of the innovation cluster. Every stakeholder must feel that they will receive some additional benefits and added value from the membership, which would not be available, and which would disappear without support and collaboration of the IoT Rapid-Proto Labs project. Collaboration must be based on mutual trust and open communication, members must also be willing to share their skills and knowledge with others. The management of IoT Rapid-Proto Labs must support the flow of information and ease of contacts, responsibilities and ownerships must be made clear. A steering board could provide guidance on the overall strategy and participate in performance assessments and overall evaluation.

The key performance indicators related to innovation and market relevance include the number of new solutions and products developed by the project, reduced time-to-market, evidence of commercialization, sales from new to market or new to company innovations, and the number of patents or intellectual property rights. The KPIs related to the commitment of members include the number, size and type of organizations participating in the collaboration, the number of employees dedicated to the cooperation and the number of university-business links within the cluster.

5.1.2 Facilitating Sustainability

IoT Rapid-Proto Labs needs to consider ways to attract and involve new members into the innovation cluster. New members would offer the IoT Rapid-Proto Labs project many opportunities and support its sustainability. New members could offer the innovation cluster new skills, knowledge and resources and enable the project to broaden its scope and portfolio of solutions and services. IoT Rapid-Proto Labs could also broaden its geographical area of operations with new members located outside the current area covering Finland, Italy, Germany and the Netherlands. It must however be ensured that the extension of the consortium does not complicate the efficiency of the collaboration or the trust and openness within the cluster.

Benchmarking cases where open innovation and innovation cluster operating model have been central should be identified to compare and discover best practices and new opportunities. This could include peer reviews with other European University-Business innovation clusters.

The consortium and management of the IoT Rapid-Proto Labs must be agile and flexible to adapt to changes within the innovation cluster. If a member decides to leave the innovation cluster, the remaining members must still feel that it is worthwhile to continue in the collaboration. Intellectual property rights and commercialization incentives must be mutually agreed upon.

Promoting the project will raise awareness and interest, and might lead to new partners, funders and project assignments. Promotion must emphasize the benefits the innovation cluster offers the innovation cluster members, the customer companies and the industry and market, and have a strong scientific profile. The solutions and products that have already been developed must be advertised and the value the end-user companies have gained from the collaboration, as well as the research infrastructures and testing and piloting facilities that can be offered. Promotion should include members of the innovation cluster actively participating in seminars, hackathons and workshops to advertise the services and possibilities it offers. Promotion should also include customer endorsement.

KPIs for sustainability should include facilitating and networking as IoT Rapid-Proto Labs seeks to accelerate IoT product development by bringing together higher education institutions and businesses and to develop the skills and employability of students. Multi-disciplinary and cross-sectoral research and development should also be included in the KPIs and the number and size of the members of the collaboration. Key performance indicators for academic research and knowledge creation should include the attractiveness of the course curricula, the number of students enrolled or completed in the course, course feedback, the number of projects in progress, the number of patents or intellectual property rights, number of annual publications and number of thesis related to the project.

IoT Rapid-Proto Labs is currently fairly invisible in the in the media and the society at large, KPIs for visibility and media coverage should include the number of media hits including seminar presentations, articles and interviews.

5.1.3 Financing and Funding

For the success and sustainability of the IoT Rapid-Proto Labs, the funding model of the project must consist of multiple financing sources, both public and private. This will ensure that the research and development is advanced but still relevant to market needs and help the project to continue when one source of funding is no longer available.

Public funding was identified as a critical factor for the success and sustainability of innovation clusters in this research. The different sources for public funding identified in the research applicable for the IoT Rapid-Proto Labs include the EU, European Investment Fund, European Research Council Business Finland, Sitra, Helsingin kaupungin Innovaatiorahasto, Helsinki-Uusimaa Regional Council and Teknologiateollisuus.

Haaga-Helia University of Applied Sciences could apply for public funding independently or together with University of Leiden, University of Trento and Technical University Delft. Public funding options in Italy and the Netherlands should also be examined.

As public funding was critiqued in the research to be unpredictable and sometimes unjustified, IoT Rapid-Proto Labs needs to also consider different sources of private funding to ensure the sustainability of the project and cover operating costs. The sources of private funding applicable for the IoT Rapid-Proto Labs include membership fees and commission fees.

Membership fees should not be an obstacle to participation for any member so they should reflect the size and type of the organizations and their levels of activity in the collaboration. Members of IoT Rapid-Proto Labs should feel that they gain advantages from the collaboration they could not achieve by themselves to justify the membership fees.

With commission fees, IoT Rapid-Proto Labs could charge the clients for the research and development of the ordered products and solutions. As with membership fees, commission fees should reflect the size and type of the client organization and should not be an obstacle for assignments. IoT Rapid-Proto Labs could broaden the scope of its development assignments from Start-ups and SMEs to include also larger companies with smaller, more focused projects.

Different institutions and channels for industry funding in Finland, Italy and the Netherlands should also be examined.

KPIs related to financing and funding that need to be monitored include the percentage of public funding of the total funding, the percentage of EU-funding of the total budget, the percentage of private funding of the total funding, the number of industrial partners and their contribution to the total budget and the ratio of national and international funding sources and their contributions.

5.2 Assessment of the Quality of the Results

In this chapter, the validity, reliability and the role of the researcher throughout the research process are discussed.

Validity

Validity refers to the appropriateness of the measures used in the research, the accuracy of the data analysis and the generalisability of the findings. (Saunders et al. 2016, pp. 202.) This study can be considered valid as the seven expert interviews included established innovation clusters and their representatives that had no personal connection to the IoT Rapid-Proto Labs and therefore had no biases that could affect the study. Chapter 3 explains how the interview questions were designed, how the interviews were conducted and how the findings were analysed. The research results were coherent and had occurring themes that can be generalized, the research findings also support the literature review thus ensuring the validity of this research.

Reliability

Reliability refers to the replication and consistency of the research. A research can be considered reliable if a researcher can replicate an earlier research design and achieve the same findings. (Saunders et al. 2016, pp. 202.) One way to generalize the theoretical findings of the study is to examine published literature to see if the theory appears to hold in the settings and circumstances described by other authors. (Rubin & Rubin 2012, 190-210.) To ensure the reliability of this research, the research questions were clearly defined. Each stage of the research has been reported in a fully transparent way so others can judge the validity and reliability of this research for themselves and replicate the study if they so desired. The interviewees had first-hand experience from the research topic and the interview questions were designed so that they addressed the personal experiences of the interviewees. The interviews were conducted in a way that ensured the anonymity of the interviewees. The researcher was an external researcher as I was not working for or participating in the IoT Rapid-Proto Labs project, which ensured the objectivity of the researcher. The research results have a connection to the theories of the literature review and support the recommendations to the sponsor project. In this respective the research and the results can be considered reliable.

Role of the Researcher

In this study, the researcher had no personal connections to the sponsor of the study as I was not working for or participating in the IoT Rapid-Proto Labs project. This ensured that I had no biases or personal agendas that could affect the research process or outcome of this study. With over 15 years of work experience from the ICT sector the topic of IoT was very interesting to me and combined with my business studies and interests of modern learning and innovation theories provided me a unique position and possibility to conduct this research.

6 Conclusions

In this chapter, the answer to the research questions are stated. Suggestions for further research are also represented and the researcher reflects her own learnings.

This study was done for the European transnational multidisciplinary project IoT Rapid-Proto Labs, which is coordinated by Haaga-Helia University of Applied Sciences and funded by European Union Erasmus+ Knowledge Alliance Programme until the end of 2020. IoT Rapid-Proto Labs seeks to accelerate Internet of Things (IoT) product development by bringing together higher education institutions and businesses and to develop students the multi-disciplinary skills most European companies feel they currently lack. The main research question was to identify the sources of support within the IoT industry available for the IoT Rapid-Proto Labs project after EU project funding ends in 2020. This objective was supported by the sub-questions studying the drivers and obstacles for the success and sustainability of University-Business innovation clusters and the different financing and funding models and options for them.

The study was executed with action research approach and data was gathered using qualitative research methods including literature review and seven semi-structured expert interviews.

The research met the set objectives and gave insights on the success and sustainability of University-Business collaboration and different funding options. The results from the seven expert interviews were applicable to the theoretical framework. The main findings were that clear and shared goals and visions, mutual trust and commitment support the success and sustainability of University-Business innovation clusters. The research and development activities must be relevant to today’s market needs and the collaboration must be beneficial to all stakeholders. Funding must be long-term and predictable and include both public and private funding sources as multiple sources of financing and funding ensure the success and sustainability of University-Business innovation clusters.

6.1 Suggestions for Further Research

This research included only innovation clusters that were active during the research. Further studies could be conducted to concentrate on innovation clusters that weren’t able to progress from the early initiation and evaluation phase after the initial funding run out. Finding reasons why the collaboration was not viable and why the innovation clusters were not able to attract additional funding would give important insights and guidance.

In many of the interviews conducted for this research, public funding was critiqued to be unpredictable, unfair and not transparent. Further research could be conducted to see if there are patterns in which applications were accepted and which refused, and the reasonings for the decisions.

One area of further research could include the financing and funding higher education institutions allocate to their own research and development projects. Studying which projects were funded and which not would provide valuable insight on what type of projects the higher education institutions regard important and productive.

6.2 Reflections on Learning

I feel quite passionate about collaborative development and innovation and am interested in the modern learning theories including life-long learning and gaining of relevant multidisciplinary skills, which is why I decided to begin my Master of Business Administration studies in 2017. Also, I am interested in technological developments due to my extensive work experience in the ICT sector. Therefore, the assignment for this thesis from the IoT Rapid-Proto Labs felt highly fascinating.

The research process took a year, the research was conducted alongside a full-time work, studies and personal circumstances of the researcher. The literature review and the definition of the research questions took the longest as the personal interest of the researcher in the topics made it difficult to narrow down the research and to specify the research objectives. Even though I had never personally met the interviewees before, the interviews were easy to conduct, and I feel they obtained a sense of mutual trust and sincerity. The coding and the analysing of the results were also time-consuming.

I feel that I can utilize the learnings I have gained during this research process in the future. With larger projects such as a thesis it is important to remember to work continuously to keep up the momentum. It is also important to ask for help and guidance, therefore I kept in touch with the supervisor regularly and applied the feedback throughout the entire study.

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Appendices

Appendix 1. Interview Questions

1) The success factors in University-Business Innovation Clusters
    a) Please describe the xxx project and how you have participated in the project?
    b) Do you have prior experience in University-Business collaboration? If so, please describe these projects.
    c) Have the University-Business cooperation projects you have participated in been successful in your opinion? Please explain why / why not?
    d) What do you consider is the most important added value for your organization to participate in University-Business cooperation?

2) Factors that contribute to the sustainability of University-Business Innovation Clusters
    a) Considering the xxx project, which factors in your opinion have supported the sustainability of the collaboration?
    b) In your opinion, what factors and practices enable a University-Business cooperation project to move from the early initiation and evaluation phase towards a sustainable collaboration model?
    c) Based on your experience, what are the drivers and practices that support the sustainability of University-Business collaboration?
    d) Based on your experience, what are the impediments and obstacles to the sustainability of University-Business collaboration?

3) The financing and funding sources for University-Business Innovation Clusters
    a) Please describe the different funding models for the University-Business cooperation projects you have been involved with?
    b) What kind of role does public funding have, in your opinion, in the success and sustainability of University-Business collaboration?
    c) What kind of role does membership fees and industry funding have, in your opinion, in the success and sustainability of University-Business collaboration?
    d) What means would you see effective in attracting additional financing and funding for University-Business collaboration?

4) In conclusion is there any additional comment you would like to state related to the interview before?