The Influence of Digitalization on Industrial Startups in the Netherlands

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Preface

After three years of studying Management of Technology at the University of Technology Delft, I can hereby present to you my thesis. With this thesis, my academic career will come to an end. After finishing a bachelor in Mechanical Engineering at the University of Applied Science in Utrecht and a master in Management of Technology at the University of Technology Delft, I can look back with pride on what I have accomplished. Additionally, I had the opportunity to study abroad for one semester in Finland during my bachelor and in the United States during my master. I really enjoyed these exchanges and learned a lot from them.

After my open application at Siemens, I received an offer to write my thesis about this topic. I was always interested in entrepreneurship and adding to this the fact that I am a small business owner myself, I could not resist this offer. This report is intended for startups that are interested in using digitalization, as well as organizations that are developing digitalization solutions.

At first I would like to thank my supervisors Victor Scholten and Johannes Gartner, for supervising me during this period of research and giving me the right amount of freedom that I needed.

Secondly, I would like to thank my colleagues at Siemens for supporting me. I would like to thank Daniel Kofman in particular for supervising me during my research, brainstorming with me and helping me during these past few months.

Thirdly, I would like to thank the startups and especially the interviewees for their time and insights. Without these insights it would not have been possible to create such interesting data.

Finally I would like to thank my friends and family for the love and support me during my whole academic career, especially during the last few months.

I would hereby like to present my thesis to you. Enjoy reading it, and may you gain something from it.

Sincerely yours,
Robin van Dijk
Delft, September 2023

Executive summary

90% out of all startups fail, which is the cause of several reasons like lack of funds, lack of market need and bad management among other things. Digitalization can help startups to solve these problems, by performing processes more efficient than when they are performed manually.

The objective of this research is to build a model to estimate the average influence of digitalization on the success of a startup in all phases during their lifecycle among other established factors, according to their own input. Moreover, this research will investigate the current use of digitalization at industrial startups and how digitalization can help industrial startups to accelerate their innovations. Additionally, this will result in a few examples of how digitalization is used today at startups and a number of recommendations for further research.

This research focuses on industrial startups that are located in the Netherlands, because the Netherlands is a leading high tech country with a world class technical university and science hub and for the reason that similar research has been done in several other countries, only no research has been found on the impact of digitalization (on industrial startups) in the Netherlands. This research will answer the following main research question and sub-questions:

Main RQ: *How can digitalization help industrial startups to accelerate their innovations?*

SQ1. *What are the obstacles that industrial startups in the Netherlands run into during the startup and transition phase?*

SQ2. *How do startups evaluate their digitalization strategy?*

Employees from eight startups have been interviewed during qualitative exploratory expert interviews. These eight startups are divided in two groups. The first group will entail five startups that are currently in the early stage startup phase and the second group will entail three startups that are currently in the scale up phase. During the analysis of the data, the startups (and their data) in the first group are compared with each other. After this, the startups (and their data) in the second group are compared with each other and at last, (the startups in) both groups are compared with each other.

The different obstacles from startups resulted from different research methods. The obstacles that were found during a literature review are: a lack of funds, lack of market need, lack of experience, bad management, premature scaling and a strong competition. From the interview with the investment director of YES!Delft the following obstacles resulted: lack of long term vision, producing everything in-house, going to the market too late, not separating main and side issues & not clearing obstacles in the near future before they run into them. The startups came up with some similar obstacles, but also different ones, like finding (new) people, sales and/or customer acquisition, cybersecurity, lack of funds, big geographical distances, strict/heavy legislation, finding suitable (scalable) software programs, maintaining high quality standards, long negotiation times with customers and decisions of widening/narrowing the product portfolio.

All startups stated that digitalization is very important (one even called it a *key success factor*), however only three startups could give some kind of definition of what it is exactly and only two startups have a digital roadmap. Even though several startups stated that they would recommend to other startups to start as early as possible with digitalization, they all stated that digitalization is the least important in the first two phases of a startup compared to the last two phases.

The examples of applications that startups mentioned, range from the more simple examples like online meetings and 3D modelling software, to the more advance examples like an ERP system, MES system, machine learning models and newly created API's. With the help of these applications of digitalization, startups can save time and money in the long run.

During this research it became clear that digitalization can accelerate the innovations of industrial startups, but it is not the most important factor and cannot carry a startup on its own. Digitalization is a tool to get somewhere and not a goal on itself.

The contribution of this research to the literature is a conceptual model that has been used during this research to measure the influence of digitalization (among other variables) on the success of industrial startups in the Netherlands. The practical contribution of this research for startups is to create awareness among startups about the influence of digitalization, the fact that startups can read about the obstacles that they could encounter and some possible solutions for these obstacles as well. Companies that offer applications of digitalization can use this research as orientation for the creation of tailormade digitalization solutions for startups.

Recommendations for further research are: to dive deeper into the phenomenon digitalization, to investigate why some startups say that digitalization needs to be used early, but then contradict themselves with filling in the conceptual model, the influence of digitalization at startups in other sectors and the influence of digitalization among larger corporations.

List of Abbreviations

5G	5th generation mobile network
AI	Artificial Intelligence
API	Application Programming Interface
CAD	Computer Aided Design
EBAN	European Business Angel Network
EIB	European Investment Bank
EIBIS	European Investment Bank Investment Survey
ERP	Enterprise Resource Planning
ESM	European Startup Monitor
EU	European Union
EURADA	European Association of Development Agencies
CPS	Cyber-Physical Systems
ICT	Information and Communication Technology
IIoT	Industrial Internet of Things
IoT	Internet of Things
KPI	Key Performance Indicator
MES	Manufacturing Execution System
MS	Microsoft
MVP	Minimum Viable Product
RQ	Research question
SME	Small and Medium-sized Enterprises
SQ	Sub-question
TCO	Total Cost of Ownership
TSN	Time Sensitive Network

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1. Introduction

This chapter will give an introduction to this research. This introduction contains some information about the background, the problem statement, objective and the scope of this research, as well as the scientific and practical relevance, the research questions & methods and this chapter will end with an outline of the rest of the research.

1.1. Background

In the beginning of the 18th century human productivity has risen significantly, because of the invention of the steam engine and the application of this for manufacturing purposes (Sharma, 2020). This invention was used for innovations such as the steamship and locomotive, but at first it was used in the clothing industry in the shape of a mechanical loom. This water and steam powered manufacturing was the first industrial revolution.

A century later, because of the invention of the conveyor belt, production was speeded up once again. This was all put in motion as a result of the invention of electricity. Originally factories where powered by steam engines. This turned out to be more complicated than machines which are powered by electricity that could simply be plugged into a power point (Forrester, 2016). The most well-known first application of the conveyor belt was by Henry Ford, when he revolutionized the car manufacturing process. As a result of this, cars were being built on the conveyor belt in partial steps, while a car was always installed on one platform completely. These inventions were created during the second industrial revolution (Sharma, 2020).

In the beginning of the 20th century the first startups where founded (like IBM for example in 1911) (Przem, 2016). Later this century, the third industrial revolution took place which was marked by the introduction of automation. This meant that activities that used to be executed manually, were now automated by means of electronics and IT (Klingenberg, 2017). Concrete examples of this automation are robots that are running program sequences without human interference (Klingenberg, 2017).

It was not until the dot com bubble (around the year 2000) that the term startup became more well known among the greater public (Przem, 2016). This was also the period that famous (back then) startups were established like Google, Facebook and Amazon. Currently, the fourth industrial revolution is coming up or so called: digitalization (or Industry 4.0). Digitalization builds further on the third industrial revolution and is all about the digital connection with and between manufacturing processes (Sharma, 2020). These manufacturing processes will be extended through a network connection, which will create a virtual counterpart on the internet. This enables contact with other facilities and processes and leads to “cyber-physical manufacturing systems” and thus to smart factories (Sharma, 2020).

1.2. Problem statement

New technologies are increasingly developing around startups. Initially, a startup mainly focuses on the further development of the technology and getting it market-ready and, especially in the beginning, has no eye for a long-term vision, adding the fact to this, that 90% out of all startups fail, makes it difficult for startups these days to survive (Krishna, 2016). Research says that there are a number of reasons why startups fail, namely: lack of funds, lack of market need, lack of experience, bad management and strong competition among others (Aminova & Marchi, 2021; Krishna, 2016).

During this research, another obstacle resulted out of meetings with a digitalization expert. He concluded that due to short term vision of startups, they focus too much on getting their prototype ready. This results in a difficult continuation of the process, because of the high level of difficulty to scale up this prototype into a product that is easy to produce in larger quantities and to offer to the market for a reasonable price.

Complementary to this, an interview with the investment director of YES!Delft (a startup incubator) has taken place, which resulted in added motivation to this problem. He stated that startups that have a handful of people, still have an organization which is manageable (van Hall, 2023). When this organization grows, to for example more than 25 people, this will be difficult to handle and here digitalization can bring a solution for this problem.

In the end, when a product is produced and there is no need for this product, this startup has a huge problem. The lack of demand for a product or having difficulties with customer acquisition is one of the most common obstacles and a reason that numerous startups fail (Aminova & Marchi, 2021; Bednár & Tarisková, 2017; Kollmann et al., 2016; Krishna, 2016).

Digitalization can help startups to solve these problems, by performing processes more efficient than when they are performed manually. The problem is that startups sometimes don't know this phenomenon, and thus don't know how much it can help them. Software for this phenomenon is available only a lot of startups do not have a digital roadmap, do not know how to start with this or do not even know that it exists (Vergeer & Nerad, 2022).

1.3. Objective

This research is part of a bigger project at Siemens, of which the overarching goal is to accelerate innovation. One believes that digitalization has a lot of potential for the industry and can be beneficial by means of efficiency, sustainability and cost wise. That is why this research will focus on the influence of digitalization on the acceleration of innovations at startups.

The objective of this research is to build a model to estimate the average influence of digitalization on the success of a startup in all phases during their lifecycle among other established factors, according to their own input.

Moreover, this research will investigate the current use of digitalization at industrial startups and how digitalization can help industrial startups to accelerate their innovations. Additionally, this will result in a

few examples of how digitalization is used today at startups and a number of recommendations for further research.

1.4. Scope

The term startup is a broad term and can have many definitions. The word “startup” according to Breschi et al. (2018) & Csazar et al. (2006) means any form of business in its early stage of development. Another definition of a startup according to Skala (2019) is an agent of innovation, especially the latest achievements of science and technology, allowing the economies of developed countries, exhausted by the financial crisis, to regain their “fresh breath”. The second part of this definition does not (currently) apply to this thesis, but a combination of the first definition and the first part of the second definition will be used to identify startups for this thesis and the multiple case study. With a startup in this research is meant: *a business in its early stage of development, who is an agent of innovation, especially in the latest achievement of science and technology.*

This research will focus on industrial startups that are located in the Netherlands. This is because the Netherlands is one of the most competitive EU countries when it comes to high-tech export (Braja & Gemzik-Salwach, 2020). Many international companies located their R&D department in the Netherlands, which is assumed to be because of the knowledge transfer, innovation adoption, know-how, skilled labor force and R&D expenditures (Braja & Gemzik-Salwach, 2020). Complementary to this, the Netherlands are home of the Delft University of Technology which is the 13th best university in the world by subject of Engineering & Technology in 2023 (according to QS top universities (2023)) and home of the Brainport region in Eindhoven, which is the 7th most promising science hub in the world (according to van Overbeeke (2022)).

Industrial startups in this context include two kinds of startups. Firstly, startups that design, build and sell machines as a business model. Secondly, startups that need to design and build machines themselves, because these machines create the product which they then monetize in the end.

1.5. Scientific relevance

Digitalization is an important upcoming trend in the EU. The coronavirus pandemic helped accelerate the digital transformation of the economy in Europe (EIB, 2022). As a response to this pandemic, 46% of firms in the EU reported that they took action to become more digital. The Netherlands is, together with five other countries, one of the frontrunners of the EU according to the EIBIS Corporate Digitalization Index (EIB, 2022). This trend is already noticeable at corporations in Europe. Siemens presented an investment strategy in June 2023, to investment €2 billion in automation, sustainability and digitalization (Siemens, 2023). This investment could even increase to €2.5 billion (Siemens, 2023).

There is already a significant amount of literature written about the impact of digitalization on startups. Only this is either about startups in another country than the Netherlands (Indonesia, India, South-Africa, Croatia, etc.) or about startups in another branch (renewable energy, agriculture, finance, economics, maritime transport, etc.) (Kruger & Steyn, 2020; Susilo, 2020).

Gutmann et al. (2019) performed a case study to explore the benefits of corporate accelerators while highlighting the benefits for both parties (the corporate side and the startup side). This article is also focused on accelerating innovation at startups, but not specifically at industrial startups or by the means of digitalization.

A similar research has been performed in Finland, where six growth companies were researched to examine how digitalization can affect the firms' growth (Matalamäki & Joensuu-Salo, 2022). These researchers performed a case study to understand the relationship between digitalization and growth (Matalamäki & Joensuu-Salo, 2022). Another research has been performed in Sweden on 26 multinational manufacturing firms to discuss their digitalization efforts, the difficulties they encountered and how they can be handled (Björkdahl, 2020). In this research, a multiple case-study is performed to explore how these firms create and capture value from digital technologies, increased volumes of data involved and related problems (Björkdahl, 2020). In Germany, another research has been performed on 13 manufacturing companies to generate a deeper understanding of relevant required action to implement industry 4.0 (Veile et al., 2019).

Similar research has been done in several other countries, only to the best of the researcher's knowledge, no research has been found on the impact of digitalization (on industrial startups) in the Netherlands. These investigations were also performed on bigger companies or a mix of small and big companies. This current research is focused on startups as they are according to their definition expected to be more open to adapt innovations like digitalization.

Considering the fact that the Netherlands is frontrunner in digitalization, that many startups fail and that startups are expected to be more open to adapt new technologies like digitalization, this research will aim to answer if Dutch startups in manufacturing can benefit from using digitalization to become successful.

1.6. Research questions & methods

To address the research gap and create a better understanding of the phenomenon, the following main research question is posed:

Main RQ: How can digitalization help industrial startups to accelerate their innovations?

Accelerate here, means to shorten the time-to-market of the startup. Time-to-market is the product development time and the product introduction time combined, which defines the timespan to bring a product to the market (Droge et al., 2004). This main research question will be answered with the help of a number of sub-questions that are formulated below.

SQ1. What are the obstacles that industrial startups in the Netherlands run into during the startup and transition phase?

One needs to find out what the possible obstacles are that startups run into. However, before this, research needs to be done in the form of a literature review to uncover the phases that a startup goes through. On this manner, an overview can be created of the lifecycle of a startup. After this research, a specific part of the lifecycle of a startup will be chosen to zoom in on for the rest of the research (this will be the startup and transition phase). When this phase is chosen, another literature review will be performed to find out what the obstacles are that a startup runs into during these phases.

This sub-question will be answered by combining the results of a literature review, an interview with the investment director of YES!Delft and 8 explorative expert interviews. This investment director is an expert (specified in the area of investments and finance) in getting startups of the ground, and to guide them through difficult times and help them overcome the obstacles that startups generally run into.

SQ2. How do startups evaluate their digitalization strategy?

Once the possibilities of digitalization and the obstacles of startups in the begin phases are known, it is interesting to get to know the current state of the market. Where do contemporary startups stand right now? For this second sub-question explorative expert interviews will be performed to gather new data.

Eight startups are investigated during this research and from these eight startups, one employee of each startup will be interviewed to gain insights on how every startup evaluates their own digitalization strategy. This data will be gathered by performing face-to-face, semi-structured qualitative interviews.

These eight startups will be divided into two groups. The first group will entail four startups that are currently in the startup phase and the second group will entail four startups that are currently in the transition phase. During the analysis of the data, the startups (and their data) in the first group will be compared with each other. After this, the startups (and their data) in the second group will be compared with each other and at last, (the startups in) both groups will be compared with each other.

The table below (in Table 1) shows an overview of the sub-questions including the research methods that will be used to answer these questions and the deliverables that will result out of this.

Table 1 - Overview of the sub-questions

Nr.	Sub-question	Research methods	Deliverables
1.	What are the obstacles that industrial startups in the Netherlands run into during the startup and transition phase?	Literature review + semi-structured qualitative interview	An overview of the obstacles of a startup in the startup and transition phase
2.	How do startups evaluate their digitalization strategy?	Semi-structured qualitative interviews	An overview of the current status of digitalization at startups + a comparison of the level of digitalization at startups from different stages of the startup lifecycle

1.7. Practical relevance

The results of the two sub-questions are directly applicable for startups as well as other companies. The first question can create awareness among startups and will show what obstacles they can expect in certain points in their life. Complementary to this, they can read about some possible solutions for these obstacles.

The conceptual model that will be developed during this research can be used to create awareness among startups about the influence of different success factors including digitalization in every phase of their lifecycle. This level of implementation of digitalization from different points in the lifecycle of a startup, can be used as an example of how other startups deal with digitalization. This can be used as an example of which other startups can take knowledge from, if they are interested in this topic or considering to use digitalization for the benefit of their organization as well.

Apart from this, companies that offer products that could help with digitalization solutions, can use this as orientation for the creation of digitalization solutions to help startups conquer their obstacles. They could also get a glimpse of the current level of digitalization at startups, when they feel the need to implement this and what kind of applications of digitalization are already on the market. As a result of this, companies could react to this with tailormade products & services for startups.

1.8. Outline

This research consists of six chapters. In the first chapter the research topic, problem & research questions are introduced. Chapter two contains several literature reviews, a first version of the conceptual model, the validation of the conceptual model and the final version of the conceptual model, which all together form the body of knowledge. The third chapter will zoom in on the research approach, which research methods will be used and how the data is collected and analyzed. Chapter four displays the results of the exploratory expert interviews and will also analyze and compare this data. The conclusion can be read in chapter five, where also the research questions will be answered, the conceptual model, the contribution to the literature and the practical contributions will be discussed. Finally, the discussion will take place as well as the limitations and the recommendations for further research.

To make the whole process of this research clearer, a visual of the whole research process is created. The visualization of this research design is shown in Figure 1.

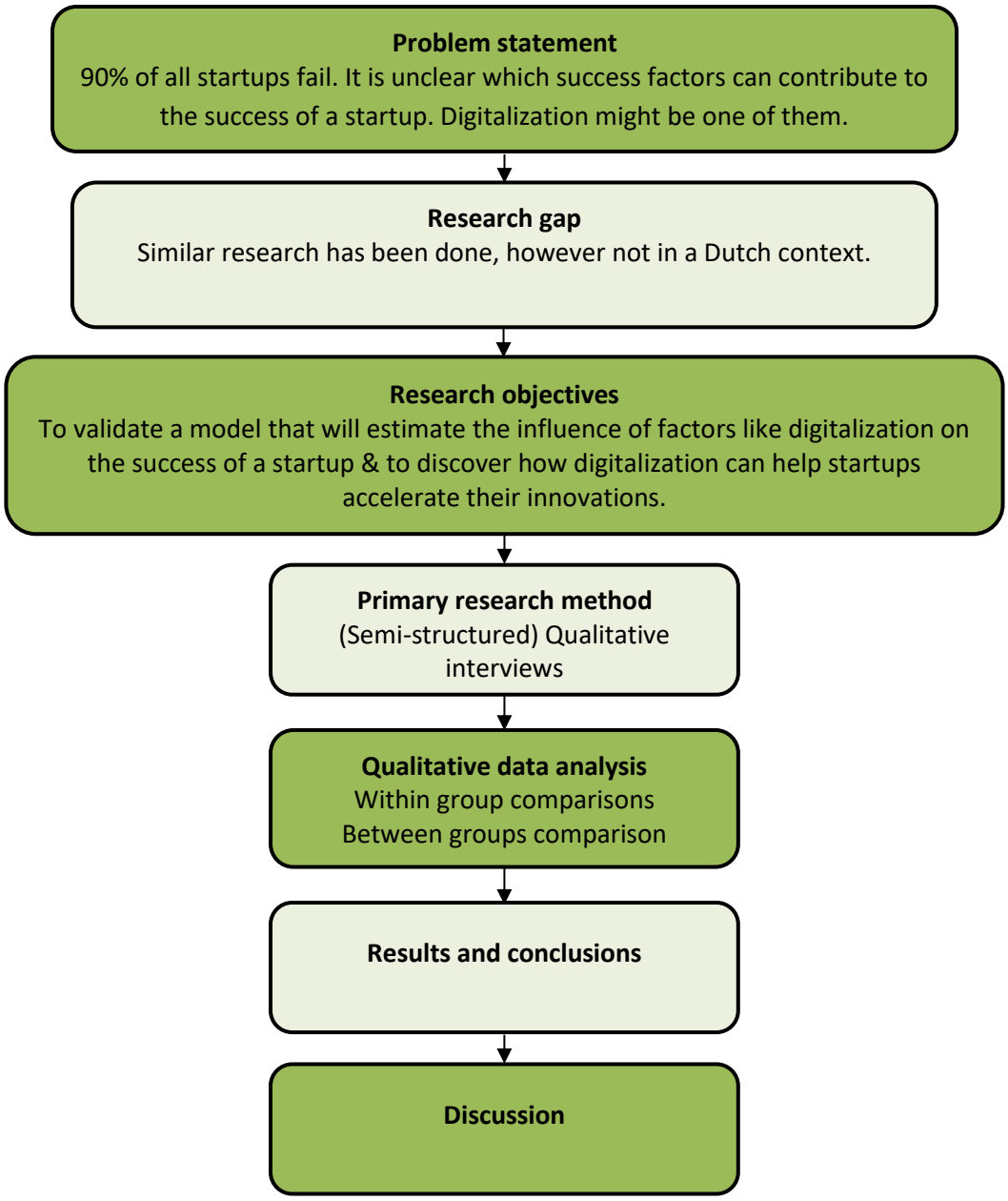


Figure 1 - Flow diagram of the research design

2. Body of knowledge

This chapter contains the literature reviews that are performed to create a body of knowledge for this research. Three literature reviews are performed during this chapter. One literature review on the topic of digitalization to create a literature based definition of the term digitalization and an extended introduction of this phenomenon. Another literature review will be performed on the phases that a startup goes through and finally a literature review will be performed on the obstacles that startups phase.

This chapter aims to answer (a part of) the following sub-question:

SQ1. What are the obstacles that industrial startups in the Netherlands run into during the startup and transition phase?

The answer of the literature review for this sub-question will be complemented with the data that will be generated by an interview that will be held with the investment director of YES!Delft and the explorative expert interviews with the eight startups. Finally, the end of this chapter will elaborate more on the first version of the conceptual model, the validation of this conceptual model and the final version of this conceptual model.

2.1. Search description and selection criteria

A number of steps are followed to make sure that the literature review studies of this research are performed in a structured way. At first, keywords are formulated which will be used as search queries. The keywords are carefully chosen, as to be expected to deliver the most relevant information to this research. An overview of the selection criteria for the literature review studies of this research is shown in Table 2.

Table 2 - Selection criteria literature reviews

Search query	Hits	Filters	Filtered by abstract	Useful literature
Digitalization	757.000	-	20	6
Digitalization	143.000	Since 2019	20	1
Industrial digitalization	306.000	-	20	0
Cyber physical systems	1.130.000	-	20	1
Phases startup	16.600	Since 2019	20	0
Lifecycle startup	49.700	-	20	5
Scaling obstacles startups	24.200	-	10	2

As a consequence of the large amount of hits, it was not possible to read all of the literature that resulted after each search query. A number of articles are read from every search query, first filtering by title, than filtering by abstract and later reading the rest of the articles. During the literature reviews, the snowball approach is used to find more relevant literature. With the snowball approach one can use the reference list of an article or the citations of an article to identify additional papers (Wohlin, 2014). This snowball approach is used to identify a number of additional papers for this research. Google Scholar is the database that is used for these literature reviews. Google Scholar is one of the available databases according to the Delft University of Technology that contains scientific resources and is accessible for TU Delft students. EndNote is used during this research to store and file the resources in a structured manner.

The first four search queries are used for the first literature review about digitalization. The fifth and sixth search query are used for the second literature review about the lifecycle of a startup and the last search query is used for the third literature review about the obstacles of a startup. It is not said that only the results of these search queries are used for these literature reviews. Some articles are used for multiple literature reviews.

2.2. Digitalization

Digitalization is a broad term in the corporate world, but still there is no clear definition of the term *digitalization* itself. Academics talk about the terms *digitization* and *digitalization* which are frequently used interchangeably in academic papers. Table 3 displays an overview of the different definitions of the term *digitization* in the literature.

Table 3 - Overview of different definitions of the term digitization

Definition of the term *digitization*	Source
"The technical process of converting streams of analog information into digital bits of 1s and 0s with discrete and discontinuous values."	(Brennen & Kreiss, 2016)
"the action or process of digitizing; the conversion of analogue data (esp. in later use images, video, and text) into digital form."	(Parvainen et al., 2017)
"The straightforward process of converting analog information to digital—turning pages into bytes, for instance, by scanning a document or uploading a sound recording."	(Gobble, 2018)

As can be seen in Table 3, there are different definitions of the term *digitization.* Below, in Table 4, the many different definitions according to the literature of the term *digitalization* are displayed.

Table 4 – Overview of different definitions of the term digitalization

Definition of the term *digitalization*	Source
"The way many domains of social life are restructured around digital communication and media infrastructures.	(Gray & Rumpe, 2015)
"The changes associated with the application of digital technology in all aspects of human society."	(Stolterman & Fors, 2004)
"Ability to turn existing products or services into digital variants, and thus offer advantages over tangible product."	(Gassmann et al., 2014; Henriette et al., 2015)

"The adoption or increase in use of digital or computer technology by an organization, industry, country, etc."	(Brennen & Kreiss, 2014)
"Digitalization does not just mean going paperless; it means being able to integrate solutions to manage, organize, control, and generate value from digital data for value creation, sustainability, and new opportunity creation for business and society."	(Parida et al., 2018)
"According to Gartner, digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; and it is the process of moving into a digital business."	(Parida et al., 2018)
"Digitalization refers to the use of digital technology, and probably digitized information, to create and harvest value in new ways."	(Gobble, 2018)
"Digitalization is one of the most significant on-going transformation of contemporary society and encompasses many elements of business and everyday life. Digitalization refers both to a transformation from "analogue" to "digital" (e.g. a shift from cash to electronic payments) and to the facilitation of new forms of value creation (e.g. Accessibility, availability, and transparency)."	(Hagberg et al., 2016)
"Digitalization is defined as the use of digital technologies and of data in order to create revenue, improve business, replace/transform business processes and create an environment for digital business, whereby digital information is at the core."	(Clerck, 2017)
"The industrial management literature defines the digitalization as the phenomenon of intelligent connected machines that information and digital technologies power."	(Lenka et al., 2017; Lerch & Gotsch, 2015)
"The term "digitalization" is not the irruption of a new revolution, but the pervasive synergy of digital innovations in the whole economy and society."	(Perez, 2015; Valenduc & Vendramin, 2017)
"Digitalization is the growing application of ICT across the economy "encompassing a range of digital technologies, concepts and trends such as artificial intelligence, the "Internet of Things" (IoT) and the Fourth Industrial Revolution"."	(Morley et al., 2018)

As can be read in the tables above, some of the definitions of *digitization* and *digitalization* are similar according to the literature. The definition of digitization that is chosen to be used in this research is as follows: *the straightforward process of converting analog information into a digital form. For example turning a page of written notes into a WORD document* (Gobble, 2018; Parvainen et al., 2017).

Digitalization on the other hand is one step further than digitization. The definition of digitalization that is chosen to be used in this research is as follows:

"Digitalization refers both to a transformation from "analogue" to "digital" (e.g. a shift from cash to electronic payments) and to the facilitation of new forms of value creation (e.g. Accessibility, availability, and transparency)." (Hagberg et al., 2016)

Therefore, digitalization does not only mean the transformation from analogue to digital. Digitalization also entails the next step, which implies that one uses this newly created digital data and automates the process or system efficiently.

According to Parvainen et al. (2017) the Finnish Tax Administration has an adequate example of the difference between digitization and digitalization. Only digitizing their process, would have meant changing their paper tax reporting form into a digital form and enabling to upload attaching receipt and certificates in a digital format as well. Instead, they renewed the entire process in a way that the tax information from employers, banks, and other income sources of citizens will be directly (digitally) received by the Tax Administration. This organization then sends the completely filled in tax proposal forms to the citizens. They only have to check, and sign the form, which saves them a lot of work and time.

However, this research is more focused on digitalization in the industrial sector. In the industrial sector for example a significant amount of data is created by the measurement of different types of sensors. When sensors are used to transmit performance data from a (leased) machine to the manufacturer, this can be seen as digitization (Gobble, 2018). The data is already there, but because of the measurement of the sensor and the fact that it is transmitted (back) to the manufacturer, it becomes digital. Furthermore, this data can be used to anticipate and prevent failures, optimize planned maintenance schedules and improve the product. When the available data is used for applications as such, this can be seen as digitalization (in the industrial sector) (Gobble, 2018).

When one speaks about digitalization, one sometimes refers to it as *industry 4.0* (Björkdahl, 2020). The confusion of these two terms is understandable, because industry 4.0 is derived from the fourth industrial revolution. The term digitalization is used as well to describe the fourth industrial revolution. Apparently, the challenges, opportunities and effects of digitalization have had a major effect on business leaders as well as politicians. According to Björkdahl (2020) every country has their own definition of *digitalization* or *the fourth industrial revolution*. A number of examples are:

Industry 4.0	in Germany
Smart Manufacturing	in the United States
Industrie du Futur (*industry of the future*)	in France
Fabbrica Intelligente (*smart factory*)	in Italy
Smart Industry	in the Netherlands

Source: (Björkdahl, 2020)

Digitalization is according to Hagberg et al. (2016) about creating data and then using this data to create new forms of value creation and/or automate a process or system efficiently. To transfer and share this data, a fast and reliable network is required. 5G is such a network, with uninterrupted data transfer speeds, unprecedented reliability and very low latencies (Khujamatov et al., 2020). These advantages of 5G (the fifth generation of mobile network) can be used in (industrial) digitalization. The possible applications range from supply and inventory management logistics to operations management through robots and motion control applications, as well as the localization of devices and items. 5G supports a variety of time-sensitive network (TSN) features and industrial Ethernet, which allows 5G to be easily integrated with existing (wired) infrastructure (Siddikov et al., 2018).

A number of applications of industrial digitalization are cyber-physical systems (CPS), Industrial Internet of things (IIOT) and Artificial Intelligence (AI). According to Nasser (2014) CPS are automated systems that enable connection of the operations of the physical reality with computing and communication infrastructures. In contradiction to traditional embedded systems, which are designed as stand-alone devices, the focus of CPS is on networking several devices (Lee, 2008). With this, CPS is following the trend of having services and information everywhere at your disposal.

Internet of things (IOT) is a concept describing ubiquitous connection to the internet, turning common objects into connected devices. Connecting these unconventional objects to the internet can improve the sustainability and safety of industries and society, and enables efficient interaction between the physical world and its digital counterpart (Sisinni et al., 2018). IIOT is a subset of IOT, which covers the domains of CPS and industrial communication technologies with automation applications. IIOT creates a better understanding of the manufacturing process, thereby enabling efficient and sustainable production (Sisinni et al., 2018). To summarize, CPS is the connection between machines creating a system of these machines all together and IIOT is the connection of machines (or CPSs) to the internet.

AI is the general term for the science of Artificial Intelligence. This technology uses computers to simulate human intelligent behaviors such as learning, judgement and decision-making (Zhang & Lu, 2021). AI is a project that takes knowledge as the object, analyzes and studies the expression methods of knowledge and uses these approaches to simulate human intellectual activities (as closely as possible) (Xu et al., 2021). Some of the startups that are interviewed for this research also use AI technology in their company (chapter 4 will extend on this).

2.3. Startups

2.3.1. The lifecycle of a startup

There is a lot of literature available on the lifecycle of a startup. This literature review already resulted in 19 different startup lifecycles. There is written about many more different lifecycle models of startups by academics, nevertheless this research only has a limited amount of time which resulted in the fact that it is not possible to review all lifecycle models of startups written by academics. An overview of the different lifecycles of a startup can be found in Table 5.

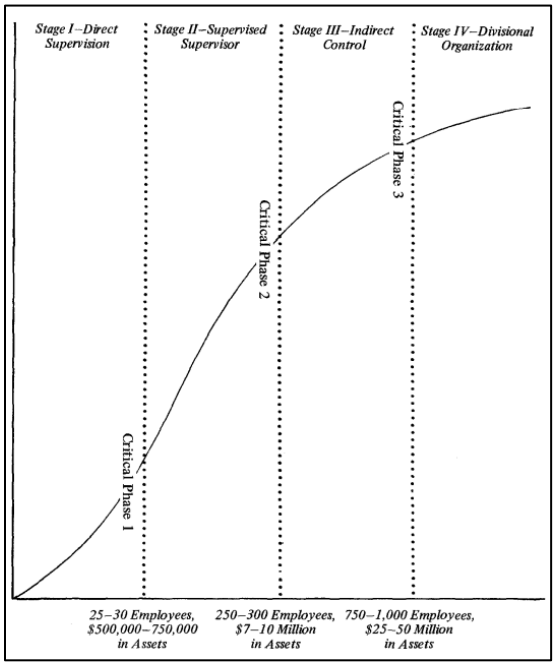
Table 5 - Different lifecycle models of startups that resulted out of the literature review

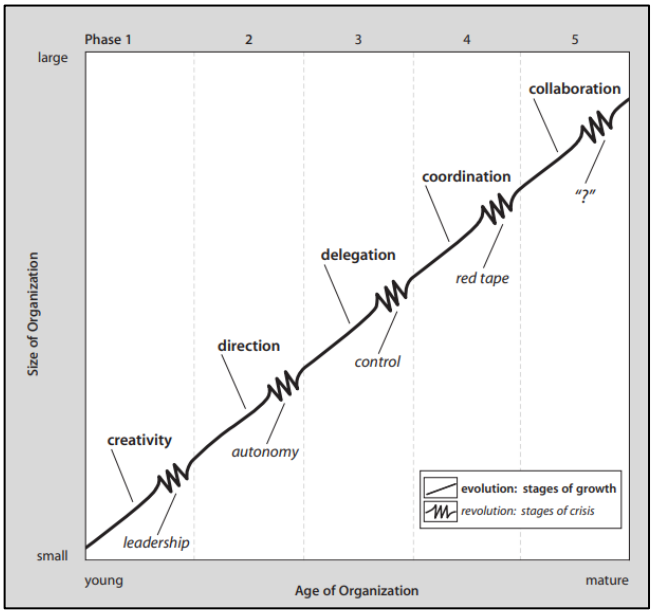
Sources: [1] (Salamzadeh & Kawamorita Kesim, 2015) - [2] (Lewis & Churchill, 2009) - [3] (Scott & Bruce, 1987) - [4] (Picken, 2017b) - [5] (Mankowska, 2019) - [6] (Paschen, 2017) - [7] (Droge et al., 2004) – [8] (Overall & Wise, 2015) – [9] (Kazanjian, 2017) – [10] (Bhave, 1994) – [11] (Kim & Ha, 1999) – [12] (Benjamin & Margulis, 2001) – [13] (Marmer et al., 2011) – [14] (Zobnina, 2017) – [15] (Sekliuckiene et al., 2018) – [16] (Lester et al., 2018) – [17] (Dufour et al., 2018) – [18] (Steinmetz, 1969) – [19] (Kroeger, 1974) – [20] (Greiner, 1998).

Source	Lifecycle model of a startup
[1]	Bootstrapping stage → Seed stage → Creation stage
[2]	Existence → Survival → Success → Take-off → Resource maturity
[3]	Inception → Survival → Growth → Expansion → Maturity
[4]	Startup → Transition → Scaling → Exit
[5]	Seed → Start-up → Early growth → Expansion → Mezzanine → Exit
[6]	Pre-startup → Startup → Growth
[7]&[8]	Pre-seed → Early stage → Expansion → Later stage
[9]	Conception and development → Commercialization → Growth → Stability
[10]	Opportunity recognition → Business concept development → Organization creation → Product development
[11]	Startup → Early growth → High growth → Mature
[12]	Seed → Startup → Product development → Bridge → Acquisition and merger → Turnaround
[13]	Discovery → Validation → Efficiency → Scale
[14]	Pre-seed → Seed → Early growth (round A) → Later rounds (B, C, D) → IPO/Exit
[15]	Bootstrapping → Seed → Creation → International growth
[16]	Existence → Survival → Success → Renewal → Decline
[17]	Creating the future → Thinking about the future → References to the past → Strategic thinking
[18]	Direct supervision → Supervised supervisor → Indirect control → Divisional organization
[19]	Initiation → Development → Growth → Maturity → Decline
[20]	Creativity → Direction → Delegation → Coordination → Collaboration

The majority of these models are based on the lifecycle models of Steinmetz (1969), Kroeger (1974) & Greiner (1998). Steinmetz (1969) is mainly focused on the critical small stages of business growth. This paper also has a model of the lifecycle of a small business, which is focused on the number of employees, the amount of assets and the type of supervision/organization. The second article, the article of Kroeger (1974), is focused on the managerial competence of the leader of small businesses. This article has a

model of the lifecycle of small businesses, focused on the managerial role of the leader of the business. The third article, the article by Greiner (1998), gives a description of the growth stages of an organization, while using the crises of leadership as a guideline throughout the whole lifecycle of an organization (the model of the lifecycle of an organization is shown in a similar fashion). The models of the lifecycle of businesses according to these three articles are shown below in Figure 2.





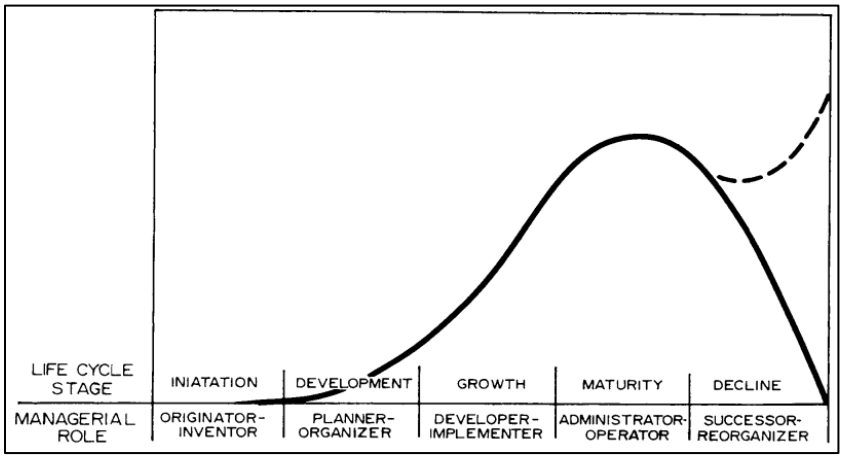


Figure 2 – Models of the lifecycle of (small) businesses according to Steinmetz (1969) (top-left), Kroeger (1974) (top-right) & Greiner (1998)(bottom)

The last article is over 24 years old and the other two articles are more than 50 years old. This makes them a good foundation for other models that show the lifecycle of a startup, but makes these models themselves not usable for this research. The model from Kroeger (1974) is a bit different compared to the other two models, because this is a linear straight line. While the model of Steinmetz (1969) is an S-curve, as well as the model of Greiner (1998) when looked at the first four phases. Another observation that can be made on these models is that they all showcase the lifecycle of a business or organization until they become an established or 'mature' company.

For this research the lifecycle model of businesses according to source number 4 from Table 5 will be used. This is the model according to Picken (2017b), which is also based on the classic life cycle models of the three previous mentioned articles. The model of Picken (2017b) is shown below in Figure 3.

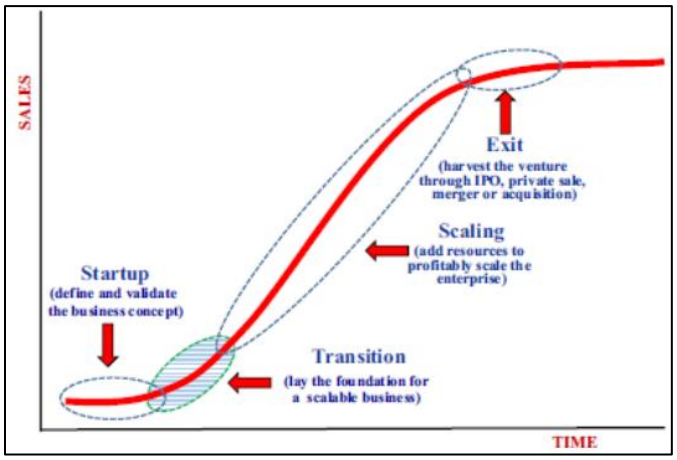


Figure 3 - The lifecycle model of a business (Picken, 2017b)

As can be seen above, this model also has an S-curve. According to this model there are four phases in the lifecycle of a business: startup, transition, scaling and exit. In the exit phase the business can no longer be seen as a startup, but is becoming an established organization. In the first three phases the business can still be seen as a startup and this research will be focusing on the first two phases of a startup (*the startup- and transition phase)*.

2.3.2. The obstacles of a startup

90% of all startups fail according to Krishna (2016) and according to Picken (2017a) "The period of transition during which a startup grows up and becomes a scalable business is arguably the most critical time in the life of an emerging firm." This results in the fact that there are several obstacles during these two phases, which be handled in this section.

There are several reasons responsible for the large percentage of failure among startups. The most well-known reason is a lack of funds (Krishna, 2016). Capital is (one of) the most important factor(s) to influence the success of a startup. When a startup does not have the needed capital, they cannot invest in their employees or the development of their product or technology. Research has shown that the lack of money for further development is the most common reason why startups fail (Bednár & Tarisková, 2017). This particular research pointed out that the lack of money for further development was the most common reason by 34% out of all 51 failed startups that took part in this research (Bednár & Tarisková, 2017). The

top 5 of most common reasons of a startups failure consists of three reasons that are money related (lack of funds, no investors and cost issues).

The second most common reason was a lack of market need for the product (Aminova & Marchi, 2021; Bednár & Tarisková, 2017). This happened to a number of startups even after they did preliminary research with potential customers. After the realization of the product, they found out that the need of the customer was not high enough to actually buy the product. This is supported by the European Startup Monitor (ESM) (2016) which performed a research among 2515 startups in Europe, which included the biggest challenges that startups are facing. According to this research, the biggest challenge that startups are facing is sales and/or customer acquisition (Kollmann et al., 2016).

More internal obstacles that startups face are the lack of experience and a bad management (Aminova & Marchi, 2021; Krishna, 2016). The founder(s) (& employees) has an important influence on the success of a startup. The educational level of the founder can be considered to be very important in terms of productivity, profitability and growth of the startup (Aminova & Marchi, 2021). Frequently, the founder of a startup has a lot of technical knowledge, but a lack of commercial knowledge (Cantamessa et al., 2018). This can result in a well-developed product, but a poor (or no) business model and business development (Cantamessa et al., 2018). When there are multiple founders, there is also always the probability of misalignment between the founders. If these problems are not solved, this can result in bad decisions, bad management, one co-founder to leave the startup or all founders to leave the startup, which will result in the complete startup to fail.

Another obstacle that is caused by the founder is premature scaling. This can happen as a result of poor understanding of the startup itself or the market. The founder can be over-optimistic and overconfident in the transition phase, which can result in premature scaling of the startup (Aboobaker, 2021). When this happens most of the time, the founder wants to make a profit by creating new users for the product, which could land the startup in a downwards spiral.

An external factor that can become an obstacle as well is strong competition (Aminova & Marchi, 2021). The strong competition is a top ten reason of why startups fail according to Bednár (2017). Strong competition can have one of two meanings. At first, the strength of the competitor. The competitor can already be established firmly into the market with a relevant market share and access to distribution channels and relevant resources, which makes this a strong competitor (Cantamessa et al., 2018). Second, there can be too many competitors which makes the market more fragmented, which makes it more difficult for new startups to gain a relevant position.

Strong competition is an external obstacle and the lack of demand and premature scaling are obstacles that originate from the fact that startups not fully understand and elaborately communicate with their (external) environment. This indicates that the environment of a startup plays an important role.

The obstacles that resulted out of this literature review are lack of funds, lack of market need for the product (or sales and/or customer acquisition), lack of experience, bad management, premature scaling and strong competition. These results will be used to compare them with the results of the interview with the investment director of YES!Delft and the explorative expert interviews.

2.4. Conceptual model

The literature reviews above are the foundation for a conceptual model specifically created during this research. This resulted in a conceptual model, as displayed in Figure 4, that can be used during this research to find out which factors influence the readiness to scale of a startup.

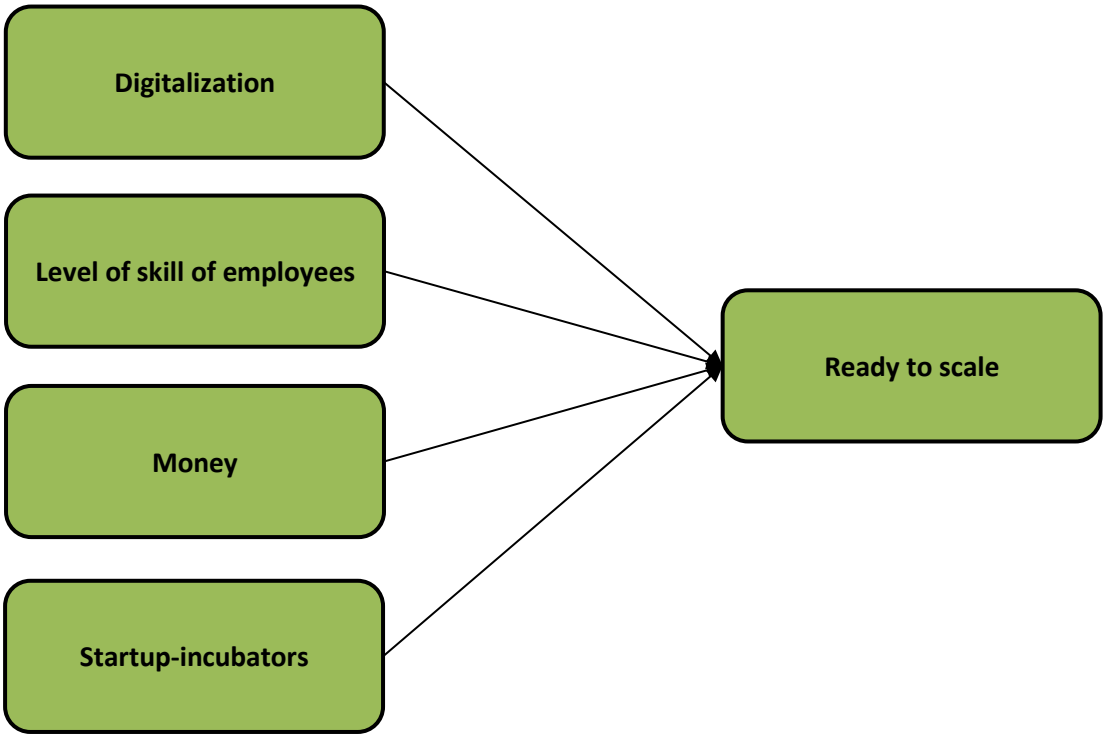


Figure 4 - Conceptual model (first version)

In this model the dependent variable (ready to scale) is hypothetically influenced by four independent variables. This model will be used during the interviews, so that it can be validated by the interviewees. By using this conceptual model during the interviews, the interviewees can give their opinion on this model and explain if they agree that these independent variables are the variables that influence the dependent variable. The goal of this model is to find out which variables, according to the interviewees, influence the readiness to scale of a startup and if they see *digitalization* as one of these variables. The other variables *level of skill of employees* and *capital* resulted out of the literature review on the obstacles of a startup.

According to Krishna (2016) capital, management and skilled individuals are some of the key factors which can help to create a successful enterprise. These variables are translated into the model as money and level of skill of employees. Like has been already said in the previous chapter, lack of funds is the most common reason for startups to fail, which makes it an important factor (Bednár & Tarisková, 2017).

Employees are another important asset of a startup, but if they possess no level of skill, than these employees are worthless. That is why this variable is formulated like this in the model instead of *employees*. “A better skilled workforce, all other things being equal, is likely to be a more innovative workforce” According to Freel (1999).

Several obstacles are mentioned in the chapter before that originate (not communicating well with) the (external) environment of startups. Startup incubators and accelerators are based on programs to help entrepreneurs and their startups to transform their ideas, technologies and products into successful products that are introduced in the market (Aminova & Marchi, 2021). These organizations provide a wide range of support services. They are focused on coaching and supervising startups to support the development and the introduction of their product into the market (Aminova & Marchi, 2021). These organizations are seen as effective ways to help startups and can be seen as one of the factors to help prepare a startup for the scaling phase. To validate the impact of this factor the variable *Startup-incubators* will be added to the conceptual model.

2.5. Validation of conceptual model

In the beginning of this chapter, a number of literature reviews that are performed to create the body of knowledge. During these literature reviews a number of variables were discovered that could have an influence on the readiness to scale of a startup. To discover if these variables (including digitalization) have an impact on this, a conceptual model is created in the chapter above. To validate this conceptual model before performing the exploratory expert interviews (and to complement the body of knowledge), an interview is done with the investment director of YES!Delft, Jan Geert van Hall[1].

YES!Delft is a startup incubator which has their own facility to house startups and help them with all the obstacles these startups run into. Van Hall has already held various positions as a business controller, finance director (CFO), director for business development and is still owner and founder of a startup which he established in 2018. Furthermore, he is a private investor (in startups) and member of the EBAN (European Business Angel Network). The EBAN is the pan-European representative for the early stage investor community gathering more than 100 member organizations in over 50 countries today (EBAN, 2018). It is established in 1994 by a group of pioneer angel networks in Europe and in collaboration with EURADA (European Association of Development Agencies) and the European Commission, EBAN invests an estimated 11.4 billion euros a year in SMEs (EBAN, 2018).

The questions that were asked to this expert are in appendix D. These questions are based on the existing body of knowledge and (answering) SQ1. The interview was divided into five parts. First the interviewer introduced himself and gave a short summary about the reason for this interview and the research. This was followed by some questions to get to know the interviewee. After this several questions were asked about the topic digitalization and the scaling up of startups (& the obstacles). Additionally, some questions were asked about the conceptual model and in the end the interview was rounded up with a closing question.

[1] Jan Geert van Hall agreed to be mentioned by name in this research.

Digitalization

Van Hall did not have a specific definition for digitalization, but he saw it divided into two parts: automation of the company processes and the development process of the product. He was also convinced that startups should not have digitalization as a goal on itself.

"Digitalization for me, is essentially performing tasks faster and with a higher quality than that is normally done by hand." (van Hall, 2023)

The startup needs to have a goal, because digitalization should be supportive to what a startup does. An example of digitalization at a startup is an ERP system. An ERP (Enterprise Resource Planning) system is a system that provides the infrastructure for all internal processes in an organization to communicate with each other. When for example a company has three main data centers, human resources, finance and manufacturing, an ERP system adds all three sub-sources into one system (Kenge & Khan, 2020). This way, employees can easily find all the data and work with this data in one system. When a startup is with a handful of people, the organization is still manageable. However, when an organization grows to, for example, 25 people or more an ERP system could be a convenient solution to help with the internal organization of a startup according to van Hall (2023).

Founders can also use websites such as Crunchbase to get feedback from the market, who the competition is and what they are doing right and wrong according to van Hall (2023). Crunchbase is a website where visitors can find company insights from early-stage startups to Fortune 1000 companies (Crunchbase, 2023). Complementary to this, it is important that startups document their steps and their actions (van Hall, 2023). Organizations have bad memories and it definitely would be a waste of time to redo test or experiments, because this was not documented well.

The scaling-up of startups

At YES!Delft they created their own lifecycle model of startups, related to funding according to YES!Funded. YES!Funded is a service from YES!Delft that supports startups in their financial lifecycle planning and helps them to secure the right funds (YES!Delft, 2019). This lifecycle is shown in Figure 5.

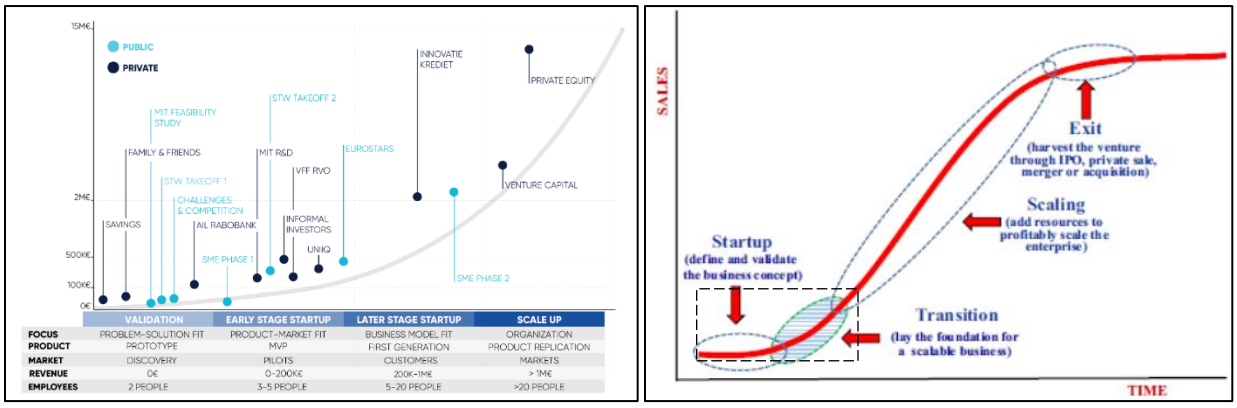


Figure 5 - Startup (funding) lifecycle according to YES!Delft (left)(2019) and the lifecycle model according to Picken (2017b)

As can be seen in the figure above these graphs follow a similar path however, the lifecycle model of Picken is more extended than the model of YES!Delft. The model of YES!Delft is more detailed than the

model of Picken. The black rectangle in the model of Picken shows the range that is displayed in the model of YES!Delft.

One of the most common mistakes by startups (or their founders), is that they have short term vision. Good founders have long term vision, make sure that they clear obstacles in the near future before they run into them and have a plan. Van Hall does not see a lack of funds as an obstacle, because the moment that startups need to invest in expensive programs for example, is mostly after they received an investment he argues. It is important for startups that they have a clear vision or long term plan and that they can separate main and side issues. The startups that understand this are mostly the startups that receive investments.

Another obstacle that startups run into, is wanting to produce everything themselves in house. If startups (want to) produce everything themselves, it could take too much time and they can only go to the market when it is too late. The founders that receive a lot of investments, are founders that have the courage to go to the market (with a product that is not perfect yet, but good enough to take to the market) and talk with customers about what it exactly is that the customer wants and needs.

"Good founders work <u>on</u> their company, bad founders work <u>in</u> their company." (van Hall, 2023)

The survival rate at YES!Delft is 80%, the reason that the other 20% did not make it is mostly due to the founder(s). A startup could still receive an investment if their product is not the best idea in the world, but if the founder is capable or has a well thought long term plan.

Investors tend to invest more in a startup that has multiple founders, compared to a startup that has a single founder. The reason for this is that startups with single founders do not have people to brainstorm with, a single founder is not critical enough on his product and when this person quits or passes away, this means the end of the startup as well.

Conceptual model

One of the most, if not the most important factor that influences the success of a startup is the founder. Like van Hall mentioned earlier, startups sometimes even receive investments if the product is not that good, but if the founder has a lot of potential and a good long term vision. This stresses the important of the founder. Next to the founder, to have skilled and motivated employees is also important to a startup. As long as a startup has the right people and everybody has the right mindset, it can conquer a lot of obstacles.

The conceptual model looks good according to van Hall (2023) only is missing a number of values like founder for example. The influence of these variables is also not the same during the life of a startup, the influence of the variables changes over time and not all the variables have an equal influence. The model should also be able to validate how big the influence of each variable is, because not all variables have an equally big influence.

2.5.1. Conclusion

Like van Hall said, digitalization is not a goal on itself for startups, but will help performing tasks faster and with a higher quality than that is normally done by hand. Digitalization will play a more important role in a startup, once it grows past a certain magnitude and can help a startup in scaling-up (with an ERP system for example).

The lifecycle model with the stages that a startup goes through according to YES!Delft has a lot in common with the lifecycle model of Picken (2017b). The model van Hall pointed out is roughly the same model as shown in the second literature review, only zoomed in to show only the startup, transition phase and the beginning of the scaling phase of the model from Picken (2017b). The phases in both models are similar as well when one compares the descriptions of the phases.

The obstacles that are mentioned in this interview however, differ from the obstacles found in the literature review:

- Lack of long term vision (short term vision)
- Producing everything in-house
- Going to the market too late and not (enough) talking with customers
- Cannot separate main and side issues
- Do not clear obstacles in the near future before they run into them

According to van Hall the conceptual model missed at least one important factor that influences the success of a startup: the founder.

2.6. Final version conceptual model and graph

After the validation process of the conceptual model, this model underwent a number of changes. The first version of the model was only able to test if these variables have an influence on the readiness to scale of a startup. This was not the right way to measure this, because not all variables have the same influence and the first version of the conceptual model was not able to measure different weights of influence. This resulted in the fact that respondents are now able to give every variable a weighing of their influence compared to the other variables. The influence of these variables also change overtime, which resulted in the addition of multiple phases in the conceptual model where respondents can give the factors a weighing regarding to their influence on that given point of time. The readiness to scale is not a good independent variable to measure over multiple points of time (in the last period in the conceptual model, (in Figure 6) the startup is already in the scale up phase) so the independent variable is changed into *the success of a startup*. The last box in the first column is left open, to give the interviewees the option to fill in another factor if they think that an import factor is missing in this model. The interviewees will be asked in the end of the exploratory expert interviews to fill in the conceptual model (that is displayed in Figure 6).

Dutch

Geef elke factor een weging m.b.t. de grootte, hoeveel deze factor bijdraagt aan het succes van uw bedrijf op het gegeven tijdstip.

English

Give every factor a weighing regarding the size, how much this factor contributes to the success of your company at the given times.

	Validation	Early stage startup	Later stage startup	Scale up
Founder				
Money				
Personnel				
Technology				
Digitalization				
...				
Total	100(%)	100(%)	100(%)	100(%)

English

Founder	Passion, creativity, perseverance of the entrepreneur/founder
Money	External funding (+ revenue)
Personnel	The people in the organisation
Technology/product	Development of the break-through technology/product
Digitalization	Digitally capturing of products and process for the purpose of scaleability
...	An option to fill in another category if you think that an important category is missing

Dutch

Oprichter	Gedrevenheid, creativiteit & doorzettingsvermogen van de ondernemer
Geld	Externe financiering (+ omzet)
Personeel	De mensen in de organisatie
Technologie/product	Ontwikkeling van doorbraaktechnologie/product
Digitalsering	Digitaal vastleggen van producten & processen t.b.v. schaalbaarheid
...	Een mogelijkheid om een nieuwe categorie in te vullen als u denkt dat er nog een belangrijke categorie mist

Figure 6 – Template of the final version of the conceptual model that the interviewees need to fill in (including the instructions that are shown to the interviewees)

Next to the conceptual model, the interviewees are also asked to fill in the graph below (that is displayed in Figure 7). This graph is the end result of combining the results of the literature review, the interview with van Hall and a number of iterations together. This graph is the lifecycle model according to Picken (2017b) only zoomed in to only show the startup and transition phase of this model. Complementary to this the more detailed phases of the model of YES!Delft (2019) are added to this graph.

The interviewees are asked to tick one of the boxes on each row of the table, which best resembles the current situation of their startup, they have to fill in the current number of people at their company and their year of establishment. On the graph they have to mark with an "X" where their startup is situated momentarily. This data will be used to compare the startups and divide them in the two groups for this research.

Dutch

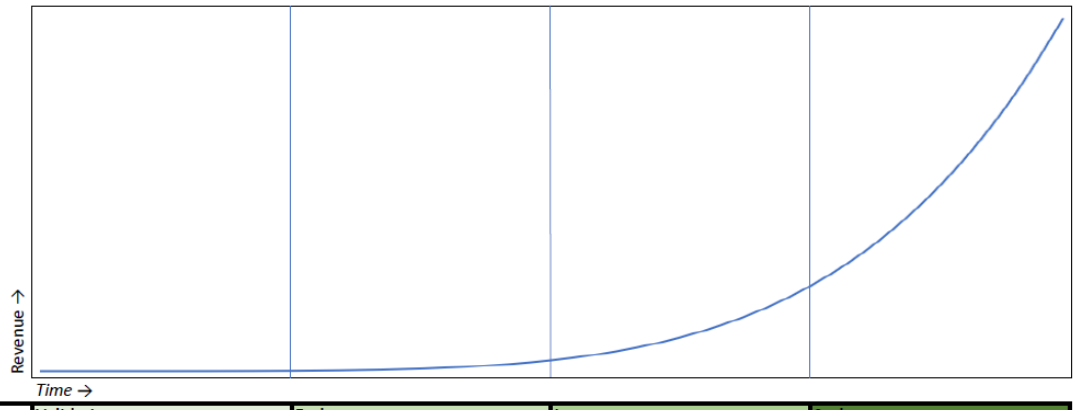
1. Zet een kruisje per rij (in de tabel) bij de situatie die het beste de huidige situatie van uw bedrijf weergeeft.

2. Zet een kruisje in de grafiek op de plek die het beste de huidige situatie van uw bedrijf weergeeft.

English

1. Tick one of the boxes on each row (of the table), which best resembles the current situation of your company.

2. Mark with an "X" on the graph, the current situation where your company is in momentarily.



Category\Phase	Validation		Early stage startup		Later stage startup		Scale up	
Revenue	Nill		First sales		Steady revenue		Profitable business	
Product	Idea		MVP		Prototype		Ready product	
Focus	Problem-solution-fit		Product-market-fit		Business-model		Marketing	

Number of people:	
Year of establishment:	

Figure 7 – Template of the graph of the lifecycle of a startup that the interviewees need to fill in (including the instructions that are shown to the interviewees)

3. Research approach

This chapter will display the research design and will zoom in more on the research methods and data collection that will be used throughout this research.

3.1. Research methods & data collection

During this research, two research methods are used. The primary research method is qualitative interviews. Primary research methods, or data collection methods, are ways in which data is collected from original sources for the specific purpose of a certain study (Sekaran & Bougie, 2016b). Qualitative interviews are a form of gathering qualitative data, which is non-numerical data (in the form of words, images or videos for example)(Nassaji, 2020). This form of data collection is the most effective method for exploratory research. Exploratory research is research about a topic where not much information is known about (Sekaran & Bougie, 2016b). For this research, it is better to gather qualitative data instead of quantitative data, because this topic is still a nascent theory (Edmondson & McManus, 2007).

The first sub-question is partly answered by a literature review and partly by an interview with the investment director of YES!Delft and eight explorative expert interviews. This will help answering the first sub-question better, from multiple points of view. The last sub-question is completely answered by performing these eight explorative expert interviews.

The last sub-question is answered by the means of explorative expert interviews. The focus for the interviewees, lies on industrial startups in the machine building sector that are located in the Netherlands. The startups are reached using the Siemens network and one's own network. After getting in contact with over 20 startups, 8 startups eventually fitted the scope and were willingly to do an interview.

3.1.1. Explorative expert interviews

Exploratory research is typically performed when not much is known about a particular phenomenon (Sekaran & Bougie, 2016a). Which makes this the right research type, because not much is known about this research topic to the best of the researcher's knowledge.

These 8 carefully selected startups will be investigated during this explorative research. These startups will be divided into two groups. The first group will entail five startups that are currently in the startup phase and the second group will entail three startups that are currently in the transition phase according to the lifecycle model of Picken (2017b). The aim for this research was to have two equally divided groups but taken into account that this is exploratory research and relies on the (subjective) input of startups, the distribution had a minor shift.

During this explorative research, multiple comparisons will be executed. A *within group comparison* and a *between groups comparison*. During the *within group comparison*, the five startups in the first group will be compared with each other to see what the current level of digitalization is in the beginning of the lifecycle of these startups. The same comparison will be made with the three startups in the second group.

For the *between groups comparison*, the complete first and second group will be compared with each other. This comparison will be made to see if there are any significant differences in the level of

digitalization between the two groups of startups and to see if the startups in the first group can learn anything from the startups in the second group. The data during this explorative research will be gathered by means of semi-structured qualitative interviews.

This explorative study will result in an overview of the current state of digitalization at startups and in a comparison of the level of digitalization at startups from different stages of the startup lifecycle.

3.1.2. The interviews

An explorative research often relies on qualitative approaches to gather data (Sekaran & Bougie, 2016a). Qualitative approaches to gather data are informal discussions, interviews, focus groups and/or case studies (Sekaran & Bougie, 2016a). For this research, (face-to-face) interviews are chosen as the method of data collection during this explorative research. With face-to-face interviews, the interviewer can directly clarify doubts and makes sure that the responses are properly understood. The interviewer can also pick up nonverbal clues and can create a safe and comfortable atmosphere (Saarijärvi & Bratt, 2021).

The disadvantages are the geographical limitations, which create a significant amount of (travelling) time, and the respondent might feel uneasy about the anonymity of his responses, because of the fact that the interviews are face-to-face (Sekaran & Bougie, 2016b). The geographical limitations issue can be tackled by creating a structured planning, which makes sure that there is a minimal waste of time. Moreover, the anonymity issue of this explorative research will be tackled by creating an informed consent form, which the interviewees can read (and sign) before the interview. This form explains that all the data which results out of the interviews will be handled with utmost discretion and will be anonymized in this report. The informed consent form is shown in appendix C.

The method of semi-structured interviews is used during the qualitative interviews. With this method, a set number of questions (that need to be answered) can be prepared on forehand, but this also leaves room for follow-up questions that could provide additional insights in the startups (Adeoye-Olatunde & Olenik, 2020).

For this research, eight startups are interviewed. These startups are all machine building startups, however they operate in the different industries. People with different positions are interviewed. The intention was always to interview an employee at C-level or the founder of the startup, but this was not always possible, because of the availability. A description of the startups that are interviewed, including the size, age and function of the interviewee at the startup are displayed in Table 6.

Table 6 - Description of the interviewed startups

Nr.	Sector	Size (nr. of people)	Age (year)	Interviewee
1	Energy industry	51-100	6	Systems architect
2	Manufacturing industry	21-50	7	Product director
3	Mobility industry	0-5	1	Founder
4	Chemical industry	21-50	8	COO
5	Manufacturing industry	21-50	8	Senior project manager
6	Chemical industry	6-20	3	CTO & Head of engineering
7	Manufacturing industry	51-100	8	CTO
8	Manufacturing industry	6-20	1	CEO

These startups also have different business models. Three out of these eight startups design, build and sell machines as a business model and three startups that design and build machines themselves, because these machines create the product which they then monetize in the end.

One of these startups has created a new business model, by selling their machine to the customer while the customer also needs pay per unit of product that they produce. Complementary to this, one startup has the option for customers to buy machine or lease the machine and pay per unit of product that they produce.

3.1.3. Data reduction & handling

During the interviews first a number of questions will be asked and in the last part two models will be shown to the interviewees, which they will be asked to fill in according to their startup (in the past, present and future). The first model will entail a graph where the startups can explain where they find themselves in the startup lifecycle model. The second model will show a number of factors that can have an impact on the success of a startup, where the interviewee can fill in how this was, is and will be the case in their situation. These models are excellent tools to give a well-grounded and comprehensible comparison between the groups and the startups.

Validity and reliability

It is important to ensure that the gathered data is valid. That is why the validity and reliability of this research need to be taken into account to ensure the quality of this research. Validity is the concern if the results accurately represent the collected data (internal validity) and their generalizability (external validity) (Sekaran & Bougie, 2016c). External validity refers to the generalizability of this research, which is not relevant to this research, for the reason that this is an exploratory study. The internal validity is guarded by checking how well the results correspond to the already established theories and arguments about this topic.

The reliability indicates the extent to which this research is without bias and hence ensures consistent measurement across all the explorative expert interviews (Sekaran & Bougie, 2016c). All the interviews will be taken by the same interviewer and will use the same interview questions to ensure the reliability of all interviews.

Transcribing & coding

The interviews will be completely transcribed in WORD. In order to analyze the data in a structural way, all transcripts will be coded (which will be manually done in MS WORD as well). Coding during this research makes the data more easily accessible and retrievable and will create more structure in the data (Linneberg & Korsgaard, 2019). Inductive coding will be used during this research. Inductive coding is coding 'directly' from the data without a pre-defined list of codes (Linneberg & Korsgaard, 2019). Inductive coding is well suited for this research, because this type of coding is a good methodology when performing an exploratory study. To reduce the large amount of data three types of coding will be used: open, axial, and selective coding.

Open coding

Open coding will be used during the transcribing of the interviews. All interviews will be completely transcribed. Certain parts can already be marked during the transcriptions of the interviews. By using open coding during this transcribing process, important parts of the interviews will be marked in the complete transcription of the interview and certain themes can already be defined throughout the transcript. Open coding is used here, because with this type of coding it is possible to begin the process of coding with an open mind and to group the codes in themes according to the raw data without predefined categories (Khandkar, 2009).

Axial coding

Axial coding will be used in a later stage of the data analysis. When all interviews are transcribed completely and important parts (and quotes) are marked during the open coding phase, all important parts will all be put in one document. This will result in an overview where all questions are shown, with the answer of each interviewed startup grouped at each question. This will create a nice overview of all the different answers given per question. Axial coding is chosen as a second round of coding, because this fits perfectly with open coding and because this is a good methodology to investigate the links between concepts and categories that were developed in the first round of (open) coding process (Vollstedt & Rezat, 2019).

Selective coding

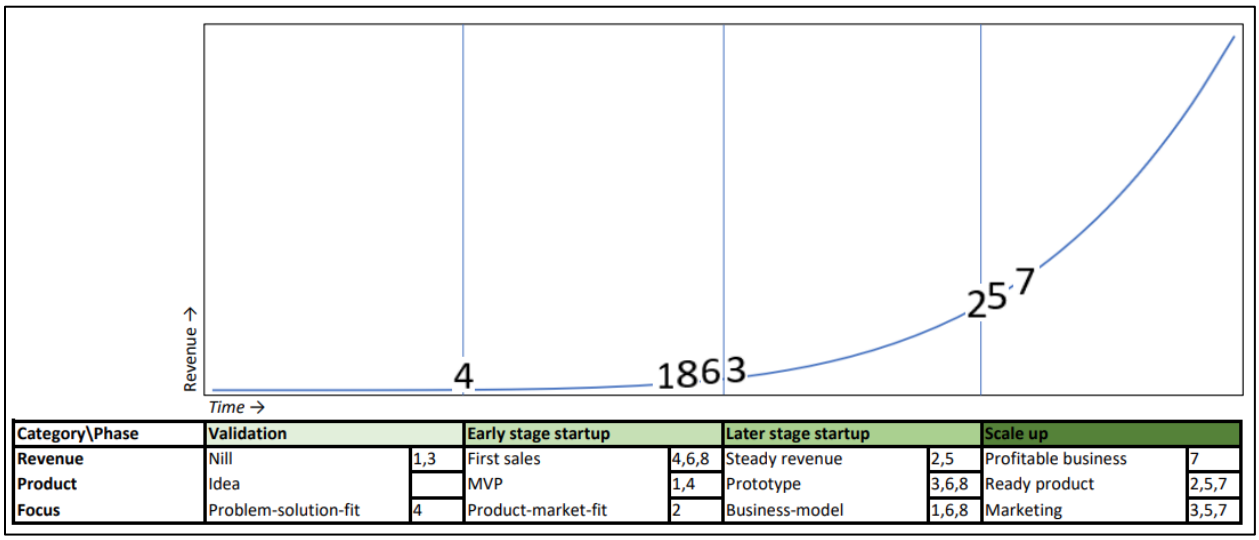
Selective coding will be used in the last stage of the data analysis. When all interviews are transcribed, and grouped per question in one big overview, selective coding is used to reduce the data to the core information of what the interviewees are saying and to create the overall picture and central opinion. This will result in a clear overview of the core information of all the interviewees grouped per question. This last type of coding is chosen, because this fits perfectly with open- & axial coding and this type of coding is more zoomed out than the first two types of coding which creates a clear overall picture and helps to integrate the different categories into one cohesive theory (Vollstedt & Rezat, 2019).

These results will eventually be used to compare the data, observe/spot patterns and to draw conclusions. These activities apply to the answers the interviewees gave on the questions, as well as on the data that is generated by filling in the two models in the end of the interview.

All the data the interviewees generated by filling in the graph, can all be plotted in one graph. The data the interviewees generated by filling in the second model can clearly be displayed by creating different new tables with; the average of the data of the startups of the first group, the average of the data of the startups of the second group and the average of the data of all the startups (of both groups).

3.1.4. Grouping of startups

During the interviews, all interviewees were asked to fill in the table according to their current situation, with the same applying to the graph where they could mark with an "X" on the graph where they think they stand momentarily. The result of this is a graph (shown below in Figure 8) with all the startups plotted together. Due to the privacy of these startups, the startups are not named but are given a random selected number instead.



Category\Phase	Validation		Early stage startup		Later stage startup		Scale up	
Revenue	Nill	1,3	First sales	4,6,8	Steady revenue	2,5	Profitable business	7
Product	Idea		MVP	1,4	Prototype	3,6,8	Ready product	2,5,7
Focus	Problem-solution-fit	4	Product-market-fit	2	Business-model	1,6,8	Marketing	3,5,7

Figure 8 - Graph with all startups plotted

When analyzing how the startups are spread, the division for the two groups is made clear. Group number 1 contains the five 'early stage startups' and group number 2 contains the three startups that are in the scale up stage. When looked at the distribution of the startups in the graph, one can also divide the startups into three groups. However, this will result in one group with only one startup (startup number 4), which is not possible, because a within group comparison needs at least two startups. The aim for this research was to have two equally divided groups, but taken into account that this is an exploratory research and relies on the (subjective) input of the startups, the distribution had a minor shift.

The questions that were asked to the startups are in appendix E. These questions are based on the existing body of knowledge and (answering) SQ1 and SQ2. The interview was divided into five parts. First the interviewer introduced himself and gave a short summary about the reason for this interview and the research. This was followed by some questions to get to know the interviewee. After this several questions were asked about the topic digitalization and the scaling up of startups (& the obstacles). Additionally, some questions were asked about the conceptual model and in the end the interview was rounded up with a closing question.

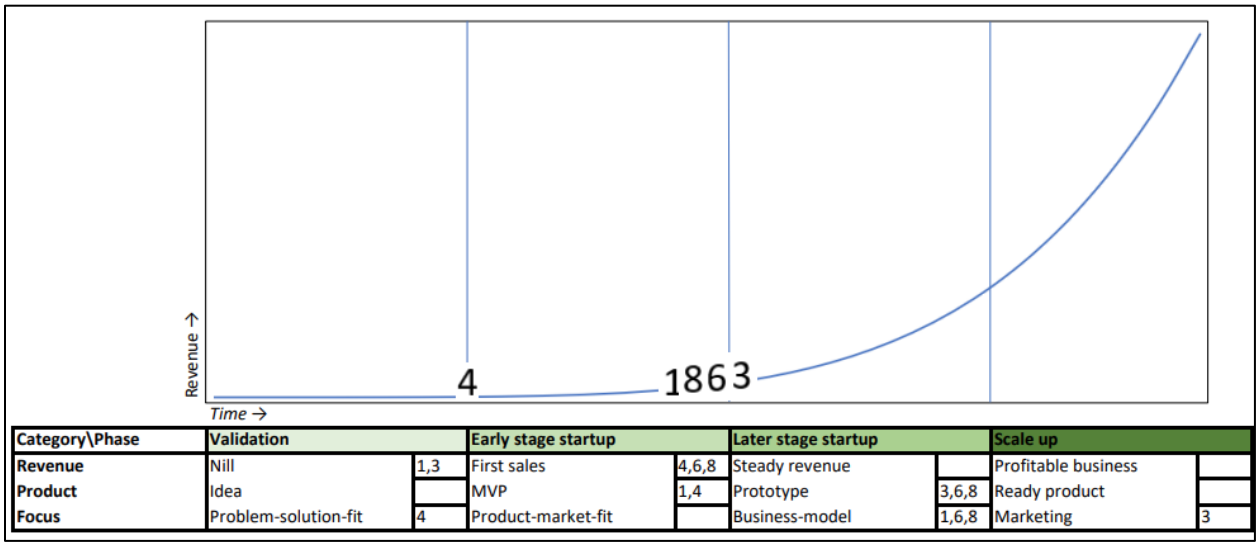
The data of these interviews will be used to answer the last sub-question, SQ2. The data of these interviews will also be used to complement the interview with the investment director of YES!Delft, in answering the other sub-question.

4. Data analysis and results

This chapter contains the results and the data analysis of the data that resulted from the exploratory expert interviews that are held for this research. These exploratory expert interviews will answer SQ2 (and will complement the answer of SQ1).

4.1.1.1. Within group comparison – group 1

Group number 1 consists of five startups, which are distributed on the graph as can be seen in Figure 9.



Category\Phase	Validation		Early stage startup		Later stage startup		Scale up	
Revenue	Nill	1,3	First sales	4,6,8	Steady revenue		Profitable business	
Product	Idea		MVP	1,4	Prototype	3,6,8	Ready product	
Focus	Problem-solution-fit	4	Product-market-fit		Business-model	1,6,8	Marketing	3

Figure 9 - Graph with all startups plotted from group 1

As can be seen in the graph, four startups are grouped around the boundary of the early stage startup phase and the later stage startup phase and one startup is positioned in between the validation stage and the early stage startup phase. All these startups filled in the table underneath the graph accordingly so, accept for the category *focus* of startup nr. 3 (this startup stated that it had already touched all of the aspects of this category).

Two startups haven't created any revenue and the other three startups are getting their first sales. The views of the interviewees differ from each other, because startup nr. 4 has an MVP and is realizing their first sales, although startup nr. 3 already has a prototype, but has not made any sales yet. This could suggest that the questioned startups have different strategies when it comes building their company. To underline this, startup nr. 1 & 3 both filled in that they are in three different stages when it comes to the three categories. Startup nr. 4, 6 & 8 on the other hand, were in the same stage with two categories and one stage behind or further with the third category.

Digitalization

When it comes to digitalization, three interviewees did not have a definition of this phenomenon, but all five stated that it was an important aspect to their startup. The definitions of the other two interviewees are as follows:

"It's about *automating the processes and at the same time adding digital capabilities that humans cannot do*." (Interviewee-1, 2023)

"Mainly that different processes are incorporated in systems, which are connected with one and another. So no more separate lists or programs, but the fact that everything is incorporated in one web." (Interviewee-8, 2023)

Many examples of applications of digitalization were giving by the startups. They were ranging from the more basic applications of digitalization like 3D modelling programs and social media to the more advance applications like programming software, real-time data management & asset management, digital twins and a future application of predictive maintenance. All startups were also convinced that they were going to use applications of digitalization as a resource that will help them during the scaling-up of their business. A 3D modelling program can be used to design and test a product (for example by running simulations with the modelling program) without already building it in real life, which can save time and money. Social media for example (like LinkedIn and Instagram) can be used to create attention and attract new employees.

"It [digitalization] is really key. For complex innovations with expensive materials it is crucial to be able to do a lot of digital testing which decreases the risk of errors and has saved us from significant spendings." (Interviewee-6, 2023)

"For all our designs we use a CAD program, because it is easy to make changes in this program to our design." (Interviewee-3, 2023)

There are also more advance applications like an ERP system, a MES system and collecting data from current products to create a digital twin to improve the product and try to create a higher quality product. One interviewee stated:

"We receive a significant amount of data from machines [in the field] so that we can check the performance of these machines and later on use this data to help improve the performance of these machines." (Interviewee-4, 2023)

What the interview states here, can be described as a digital twin. A digital twin is a virtual copy or model of a physical entity (which is called a physical twin) both of which are interconnected via exchange of data in real time (Singh et al., 2021). Applications of a digital twin differ from real-time monitoring to designing/planning, optimizing, maintenance, remote access, etc. A digital twin is used to make simulations to better the production process and to calculate KPI's for the application of the product of one of these startups.

One startup also used a program to create a digital model of a whole production factory to simulate the flow of production before they even built the production factory and another startup wants to use a data and asset management program, which registers in real-time the status of machines that are at the client, to help them with performing remote upgrades at the client.

When the startups were asked if they had a digital roadmap or a plan to expand digitalization in their company, only one of them reacted that they have a digital roadmap. One other startup was working on it, and the other three have an idea of what they want to do, but have not made a clear plan for this.

Obstacles of a startup

The biggest challenges that the startups stated where divergent between the different companies. One startup stated the following:

"Lack of funds is always re-occurring, you have to have a machine to sell, to earn money, but you need money to build a machine. It's a little bit the fish that eats its own tail, you know." (Interviewee-6, 2023)

Lack of funds was one of the challenges of a startup, including big geographical distances between them and (potential) clients and cybersecurity. Other startups had challenges like convincing customers to buy their product (some startups produce expensive machines, which means that they take more time to convince a client to invest in their product), strict/heavy legislation, technical developments and finding suitable software programs. One challenge that two startups faced was that they needed more people.

The geographical challenge is largely solved by online meetings and sharing results of experiments online, but they stated that at some point the client still wants to meet in real life and see the product, which means that this challenge can only be addressed up to a certain point. To address the strict legislation, they invested in knowledgeable people to take on this challenge and to convince clients to invest in their product, this startup showed the results of their test to convince them. To find suitable software they searched for software solutions which are scalable in a way that the software can grow (in the amount of users) along with the company. Some challenges are still being faced by startups, for which they don't have a solution for or on which they are still working.

The biggest successes of the startups vary from having a good set of skilled employees to having a working prototype and a financial plan set up. Other startups are proud that they have working machines and satisfied clients or that they had a lot of help from a sister company and that they we're able to use their facilities as well. One of the successes was that a startup was incredibly safe during their experiments, they never had any accidents during their experiments, and that they have coded every part of their machine in such a way that they were able to find back every detail about all the parts they used in every machine.

"Digitalization is an absolute must, we have learned that we should start earlier with digital tools to gain the most advantage from it." (Interviewee-4, 2023)

The most important things that the interviewees have learned is for example that it is better to be a bit more trial and error oriented instead of thinking a lot without performing any action. Another interviewee said that they would have taken more risk if they knew a few years ago, what they know now. He stated that you can reduce things that seem risky by a significant amount, just by being on top of them and addressing them. One startup wanted to have a better reliability in the past when they are looking back now, but also understands that back then functionality was their core driver and their drivers have changed over the years.

Two startups had some contradictory statements when it comes to the things they learned and the tips they have for other entrepreneurs:

"Things that seem risky, just by you being on top of them, you reduce them so much. [A tip for other entrepreneurs would be] Betting on plan A, take more risk." (Interviewee-6, 2023)

"[A tip for other entrepreneurs would be] Believe in it and have some courage, sometimes you just have to take the step. Look a few steps ahead, try to have some sort of plan B and C." (Interviewee-8, 2023)

There is something to be said for both, because if there is a plan B (and C) it can take away resources that can be spend on making plan A work. On the other hand, if plan A fails it can come in handy to have a backup plan that can act like a safety net. Furthermore, being transparent (internal as well as external), preferring long term relations over short term profit (or relations) and surrounding yourself with good people are other tips from interviewees.

A common attitude among these startups was the risk taking and hands on mentality. The interviewees were not afraid to take risks and one interviewee stated:

"Even though you have no experience, you can always learn it." (Interviewee-3, 2023)

Conceptual model

When the interviewees were asked what factors they think influence the success of their startup, different answers were given. Motivation and discipline (of the people), money, product and team where a few suggestions that match the conceptual model. Moreover, a number of new factors were also given like; the production process, reliability, customer satisfaction, TCO (Total Cost of Ownership), iteration, a good environment/ecosystem, certain design software and the suggestion to follow a certain study (mechanical engineering). Two of the interviewees suggested *market* as an important factor and one interviewee even wrote *market* on the blank space in the conceptual model for an optional addition. One of the interviewees stated:

"The most critical one [factor that influences the success of a startup] is the market." (Interviewee-1, 2023)

Out of all 8 startups (from both cases), 4 startups named *market* as an important factor and 3 startups that added a factor in the conceptual model all added the factor *market*. That is why this factor is included in the results of the conceptual model (in Figure 10). For the other startups that did not filled in this factor, it is assumed that they did not think that the market is an important factor, which resulted in zero influence in their conceptual models. As can be seen in Figure 10, the influence of the market is low but a stable influence. The interviewee that filled in this factor gave it a semi-continues influence during their lifecycle with an influence of 20%, 25%, 20% & 30% in each phase (all conceptual models filled in by the startups are shown in appendix F).

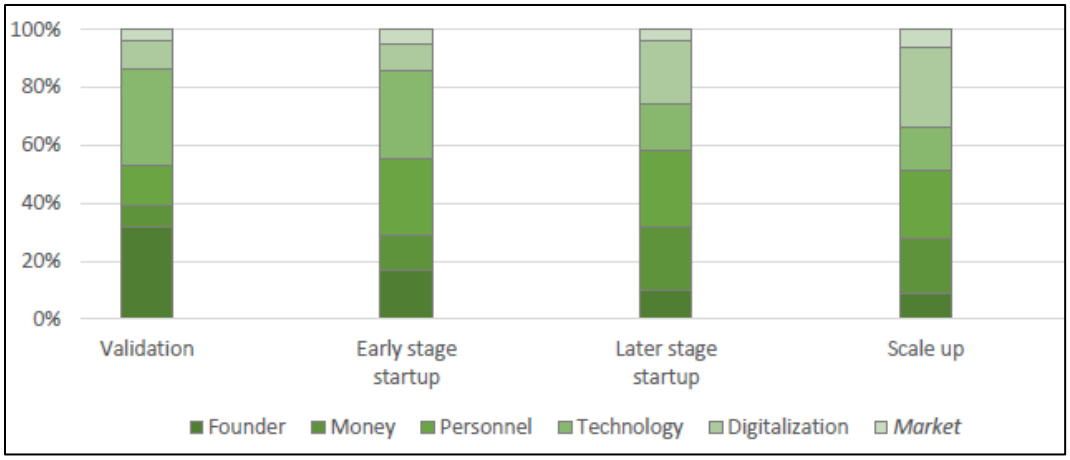


Figure 10 - Graph with the average influence of every factor on the success of a startup (per stage) of group 1

As the graph shows, the startups believe that the influence of the founders becomes less and less as the startup ages. The influence of the money and personnel has a similar flow during the lifecycle of a startup. They do not play an important role in the beginning, but later on they become slightly more important until they slightly decrease in the last phase. The factor technology and digitalization are contradicting to each other. The influence of technology starts high and becomes less and less throughout the lifecycle, as the influence of digitalization starts low and becomes more and more.

"Digitalization will be important when the volumes will be bigger and the variations more divers. In the beginning it is still manageable, but when you go towards the scale up phase you need more help in the form of digitalization so it is good to already prepare for this." (Interviewee-8, 2023)

When the models of the startups are examined, it appears that they are mostly similar. All interviewees believe the founder & technology have a similar impact on the startup throughout its lifecycle (as is represented in Figure 10). However, for the other factors the interviewees are not unanimous. Three startups think that the importance of money slowly rises during the phases, but the two other startups think that the influence of money will be rather stable. Between these two startups one thinks the influence will be around 5-10% and the other one thinks it will be around 20-25%.

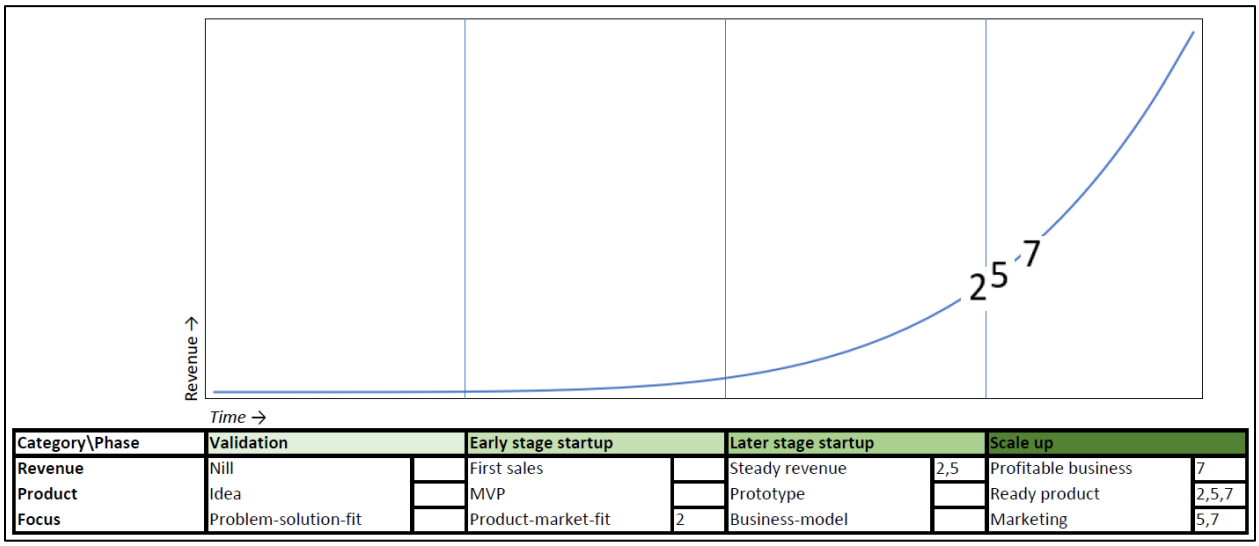
"Money has a low impact in the validation phase, but I think that this will rise significantly in the later stage startup phase." (Interviewee-3, 2023)

The factor personnel differs significantly between the startups. Two interviewees think that this will stay constant (around 20-30%), one startups states that is of no influence in the first phase and will continue to be of 30% influence in the other three phases, one startups believes that the influence will slowly rise and the last one thinks it will rise until the second phase and will then drop again in the two last phases.

With the factor technology, three startups believe that this influence will decline, however one startups expects that it will slowly rise until the second phase and that it will decline in the third & last phase and another startup expects that it will rise until the third phase and that it will decline in the last phase.

4.1.1.2. Within group comparison – group 2

Group number 2 consists of three startups, which are distributed on the graph as can be seen in Figure 11.



Category\Phase	Validation		Early stage startup		Later stage startup		Scale up	
Revenue	Nill		First sales		Steady revenue	2,5	Profitable business	7
Product	Idea		MVP		Prototype		Ready product	2,5,7
Focus	Problem-solution-fit		Product-market-fit	2	Business-model		Marketing	5,7

Figure 11 - Graph with all startups plotted from group 2

As can be seen in the graph, all startups are grouped together with one startup around the boundary of the later stage startup and the scale up phase, and the other two a bit more shifted towards the beginning of the scale up phase. The interviewees filled in the table underneath the graph accordingly so, accept for the category focus of startup nr. 2. They state that they are still working on the *product-market-fit*. However, all three startups filled in the table in a different manner, nr. 7 is in the same phase with all categories, nr. 5 is in the same phase with two categories and one phase back with the last category and nr. 2 is in three different phases with all three categories.

Digitalization

When the interviewees were asked if they had a definition of the term *digitalization* two interviewees responded that they did not have a definition of this phenomenon even though, one of these startups uses a synonym for this phenomenon (industry 4.0) on their own website to advertise its own services with. The third interviewee stated the following:

"Digitalization is one step further than industrial automatization, then [apart from automatically performing a certain task or process] you will include other peripheral matters as well like maintenance, cloud connections, data acquisition and data interpretation for example." (Interviewee-5, 2023)

All interviewees stated that digitalization is of significance importance to their startup. However, one startup stated that it plays a significant role in (the development of) their products, but a very small role in their own organization:

"On one hand we do a lot with it [digitalization] together with our customers, but on the other hand given how we run our own company, we are still working quite a lot with EXCEL-sheets." (Interviewee-2, 2023)

These startups have various applications of digitalization. One startup has their own AI software development team & uses a machine learning model in their products and they have created their own software (an API) that can communicate with the MES system of the client. Another startup has different machines that can exchange data with each other to optimize the production process. The third startup has 3D modelling software, their own digital inventory system which works with QR codes and an ERP system.

These startups are already in the scale up phase (or just start to scale up) and use these applications of digitalization to help them scaling up their business. One of these startups has plans to implement a new quality control system, that will objectively check and approve the quality of the product instead of the manual controls that are performed now by their employees who still use a checklist on paper. Complementary to this they also want to extend their inventory system by also giving subassemblies codes, so that these subassemblies can be tracked as well.

Another startup wants to prepare everything for the scaling up of the startup, perform software updates remotely and stated:

"Our number of machines in the field is growing and it's difficult to [manually] keep track of all the data. We want to automate this, but for that we need more people to develop this internally." (Interviewee-5, 2023)

The last startup did not share any future plans according to digitalization and the scaling up of their business, but acknowledged that they needed to apply more digitalization on their own organization instead of only on their products.

"Digitalization can help us to work more efficient now we're growing, however the timing for this is difficult. Too early will go at the cost of product developments, too late could result in too much overhead and inefficiency." (Interviewee-2, 2023)

They also stated that it is difficult to time these structural changes (and to find time for it), because if they work on this it would take time away from other projects that the organization would profit from in the short term (instead of the possibly even greater profits on the long term of performing these structural changes in the context of digitalization).

Out of these three startups, one of them has a digital roadmap in place. This roadmap contains plans to focus on their product portfolio and cybersecurity, to create a safer network for the startup to access their products remotely at the client. One of the other startups does not have a digital roadmap and the third one stated:

"We have a clear idea of the steps we need to take, only we don't yet know exactly how to take those steps. You often hear that with digitalization. Everyone talks about it, but nobody really knows how and where to start." (Interviewee-7, 2023)

Obstacles of a startup

All three interviewees mentioned different challenges that they face in scaling up their company. One startup faced the challenge of finding skilled people & holding onto them and convincing customers to invest in their products and another one faced the challenge of finding people as well and to make sure that they maintain the same high quality standard for their products. The last startup has a long waiting/negotiation time with future customers which can result in the startup facing certain (financial) challenges. Furthermore, they face the challenge of choosing between widening their portfolio to address more customers or narrowing their portfolio to address less customers but in a better manner.

To address these challenges, the first startup highly values cooperation with the client and spends a lot of time to build strong relations with clients to convince them to invest in their products and works together a lot with other companies in their sector to create more awareness for their startup. The second startups plans to train their new employees to maintain the high quality standard of their product and is working on an automatic quality check system. The last startup is investing in the development of their machines, has an expertise center which customers can visit and can hand out samples to customers.

One of the startups stated the following about their biggest successes:

"Working together with the customer is very important. We have such good relationships with our customers, that I can always take new/potential customers to existing customers to talk about their product and show it in a real environment." (Interviewee-2, 2023)

Another startup is proud on the clients they have and the path that they took when it comes to digitalization. The last startup is mostly proud on keeping a nice atmosphere (even though they are with tens of people), growing at a really fast pace (doubling their revenue every year for the last four years) and the fact that this is all done on their own strengths (only with the help of one investor who owns a minor share of the company).

The most important things that these startups learned is that cooperation, communication and a good relation with the client is really essential. Moreover, they also believed that trial and error is not a bad approach at all. The things that they would have done different with the knowledge that they now possess, is that it is important to make well-thought decisions. If some decisions are not well-thought, a startup could be stuck with a bad (rushed) decision that they made. One startup stated:

"The most important thing that we learned is implementing an ERP system. With the knowledge that we know now, we should have implemented this ERP system earlier." (Interviewee-7, 2023).

Moreover, they would have made better arrangements when it comes to version management. This applies to all programs and systems that a startup wants to use; the earlier that an organizations starts to use it, the easier it is to implement and work with it.

One of the tips that these startups have for other startups is to make sure to think about a lot of aspects in an early stage:

"Make sure to think about a lot of aspect in an early stage. This includes, platform choice, programming language, version-management programs, etc. It will cost a certain amount of time and money in the beginning, but will benefit an organization on the long term." (Interviewee-5, 2023)

They also stated to make sure that one stays close to their customer, to keep a good collaboration with the customer, even after the sale of the product is made, and to meet with colleague's and other (more mature) companies in the same sector.

"Go to talk with colleagues, because you can try it yourself and then find out what works and what doesn't, [work] but you will notice 10 times what doesn't work before you find out what does work. By talking to others, you may be able to skip some pitfalls." (Interviewee-7, 2023).

A lot of money and time can be saved by learning from their mistakes and talking about this.

Conceptual model

When the interviewees were asked what factors they think influence the success of their startup, they came up with quite similar factors as in the conceptual model. One startup spoke about the market as an important factor. He added that there are a lot of startups that fail, because they make a product for which eventually turns out to be no demand. Furthermore, he added having enough capital and having the right people onboard as important factors. The second startup spoke about similar factors like capital and having the right people onboard, but also about the important role of the founders and having the right ecosystem around you. At last, sales and clients (or market) were important factors of the last startup.

These interviewees were asked to fill in the conceptual model in the end of the interviews, the results of this data are displayed in Figure 12.

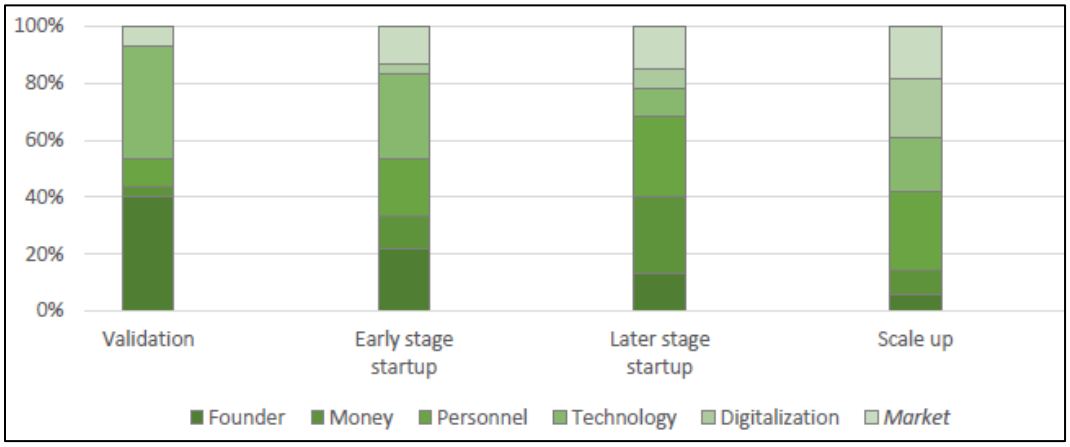


Figure 12 - Graph with the average influence of every factor on the success of a startup (per stage) of group 2

What can be seen clearly in the figure above, is that the influence of the founders rapidly declines as a startup progresses according to these interviewees. The influence of digitalization and the market in the contrary, rises during the lifecycle of a startup.

"Digitalization is not important in the beginning. Digitalization starts to become important when you go into the scale up phase." (Interviewee-7, 2023).

The others do not follow a straight line in this model, the influence of money for example rises until the third phase, but declines rapidly in the last phase. Personnel becomes more important as well until the third phase and stays equally important in the last phase. However, technology starts with a big influence, which then declines over the second and third phase, but rises again in the last phase.

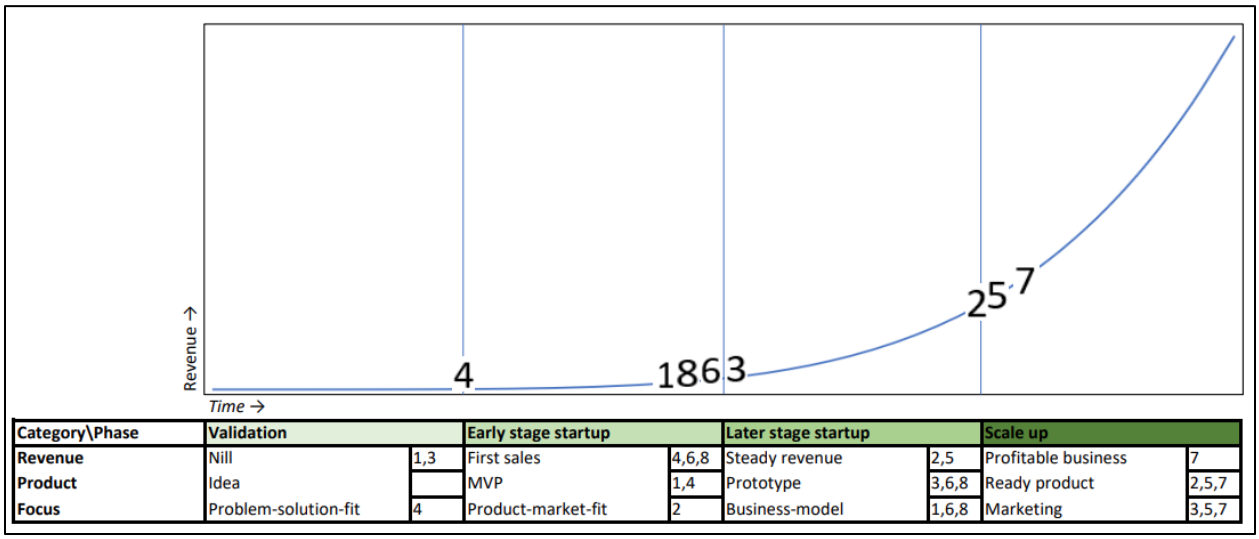
When it comes to the influence of the founder, money and digitalization on a startup, these interviewees are unanimous.

"It is important that a management team is in place to show some leadership and determine which strategy to follow [in the scale up phase], but that does not necessarily have to be the founders anymore." (Interviewee-5, 2023)

However, when we look at the factor personnel, one startup believes that this influence stays of equal importance for the first three phases, then drops a bit in the last phase. While the second startup believes that this influence rises over time and the third startup stated that this influence rises until the third phase, but then drops a little bit in the last phase. Two startups added the same factor *market* in the model, but they disagree about the influence of this factor during the life of a startup. One startup stated that the importance will slowly rise over time and the other believed that this importance rises in the first two phases, then drops in the third phase, but remains constant in the last phase. For the technology the opinions are divergent as well. One startup believes that the importance of technology stays constant for two phases, drops to zero in the third phase, but then rises again in the last phase. The second startup believes that the influence of the technology declines in the first three phases, but then rises in the last phase, while the last startup stated that the influence stays constant in the first two phases, but then declines in the last two phases.

4.1.1.3. Between groups comparison

When looked at the graph (in Figure 13), one notices that all startups are grouped around the edge of a phase.



Category\Phase	Validation		Early stage startup		Later stage startup		Scale up	
Revenue	Nill	1,3	First sales	4,6,8	Steady revenue	2,5	Profitable business	7
Product	Idea		MVP	1,4	Prototype	3,6,8	Ready product	2,5,7
Focus	Problem-solution-fit	4	Product-market-fit	2	Business-model	1,6,8	Marketing	3,5,7

Figure 13 - Graph with all startups plotted

Not one startup stated that they were in the middle of a particular phase. When the table is analyzed, all but one startup filled in that they are in more than one stage when it comes to the three categories. When the two cases are compared on this table, it can be said that the attention on the three categories of the startups in the first group is slightly more widely distributed than that of the startups in the second case. The second case has one startup that stated to be in one phase with all three categories, while the first case has two startups that stated to be in three different phases with all three categories (with one startup stated to be in the first phase with the category *revenue* and in the last phase with the category *focus*).

Digitalization

Unanimously all startups stated that digitalization is important to their startup to grow, however from the 8 startups that are interviewed, only 3 could give a definition of what digitalization actually is. These were two startups from group nr. 1 and one startup from group nr. 2, which is roughly the same share at both groups (40% in group 1 and 33% in group 2). The definitions of digitalization that were given by these startups are all quite similar to each other and the definitions that resulted out of the literature review from this research.

"It's about *automating the processes and at the same time adding digital capabilities that humans cannot do*." (Interviewee-1, 2023)

"Mainly that different processes are incorporated in systems, which are connected with one and another. So no more separate lists or programs, but the fact that everything is incorporated in one web." (Interviewee-8, 2023)

"Digitalization is one step further than industrial automatization, then [apart from automatically performing a certain task or process] you will include other peripheral matters as well like maintenance, cloud connections, data acquisition and data interpretation for example." (Interviewee-5, 2023)

Startups in both groups already use digitalization in their startups however, the level of digitalization in group 2 is more advanced than the level of digitalization in group 1. In group nr. 1 examples of digitalization are 3D modelling software, social media and the use of digitalization for market studies. While the examples of digitalization in group 2 are more advanced like a machine learning model, a self-made API, data exchange between machines, a digital inventory system with QR codes and an ERP system. This however is understandable, because these startups are also further in the lifecycle model than the startups from group nr. 1.

Startups in both groups see possibilities to use digitalization to support them in their scaling up process. Startup nr. 1 especially mentioned that they do not purchase software anymore if it is not scalable. Startup 7 talked about their ERP system which startup 8 wants to install as well, startup 1 & 7 talked about the future use of predictive maintenance and startup 4, 5 & 7 spoke about the application of remote updates in the future.

"We receive data from our machines, but we also want to perform remote updates." (Interviewee-4, 2023)

"From our headquarters we can see what the customer does with the machine and we can monitor this or steer them into the right direction." (Interviewee-5, 2023)

"We also want to perform remote updates in the foreseeable future." (Interviewee-7, 2023)

Even though all startups highly value digitalization and predict that this will have a positive influence on the scaling up of their organization, only two startups (one in each group) have a digital roadmap. When the groups are compared it looks like the startups from group 2 are only slightly better prepared when it comes to digitalization even though they are further in the lifecycle of a startup. From group 2; one startup has a digital roadmap, one startup knows which steps to take only does not know how and one knows that it has to happen only does not know how or when. Compared to one startup from group 1 that has a digital roadmap, one that is working on it and the three other startups that only have some ideas.

Obstacles of a startup

Three startups (from both groups) faced the challenge of finding people for their startup and holding on to them. Another challenge that is faced by three startups (from both groups as well) is convincing potential clients to buy their products. One startup from the first group addressed cybersecurity as a challenge, and although this was not mentioned in the second group as a challenge, one startup did address it as a part of their digital roadmap. This results in the fact that some challenges do not only occur in certain stages of a startups life, some challenges are re-occurring.

Other challenges that occurred in group 1 are; lack of funds, big geographical distances, strict/heavy legislation, developing the technology and finding suitable (scalable) software programs. In group nr. 2

other challenges that occurred are; maintaining high quality standards of the products, long negotiation times with future customers and the decision of widening or narrowing the product portfolio.

The startups did not share how they are facing the challenge of finding people and cybersecurity however, the startups from both cases faced the challenge of convincing potential clients to buy their products in different manners. The startups from group nr. 2 were able to take potential clients to existing clients or were able to invite them to their expertise center and can hand out samples, whereas the startup from group nr. 1 was only able to show test results and demo's. This is one of the fundamental differences between the two groups, the startups from group 2 are further advanced with their product compared to startups from group nr. 1.

In both groups startups call the fact that they have a working product and satisfied clients one of their biggest successes. Other successes in group 1 are; having a good set of skilled employees, having a working prototype, having the help of a sister company, being incredibly safe at experiments and having coded every part of their machine to able to find back all details about the parts. Other successes in group 2 are; having a good relationship with their customers, the path they took when it comes to digitalization, keeping a nice (work) atmosphere and the fact of achieving their current status all on their own strengths.

A common thing the startups from both groups learned, is that trial and error is not a bad way to deal with things.

"Even though you have no experience, you can always learn it." (Interviewee-3, 2023)

"I don't think that just trying is a wrong approach at a startup." (Interviewee-2, 2023)

Both agree that it is better to perform actions, make mistakes and learn from them, than to keep overthinking without any action. One startup from the first group even stated that they would have taken more risk if they knew a few years ago, what they know now. All startups from group nr. 2 learned that the earlier systems like an ERP system or an asset management system are implemented, the easier it is for the startup and the more benefit they could gain from it.

Conceptual model

The factors that startups think influence the success of their organization, differ between the two groups. The factors that were given by the startups in the first case are more specific like motivation and discipline (of the people), reliability, customer satisfaction, product, team, production process, TCO, iteration, a good environment/ecosystem and even certain design software and the suggestion to follow a certain study. The startups in the second group gave more generic factors like founders, sales and clients (a synonym for market). However, some factors are given by startups from both groups like money, team/people, market and a good environment/ecosystem.

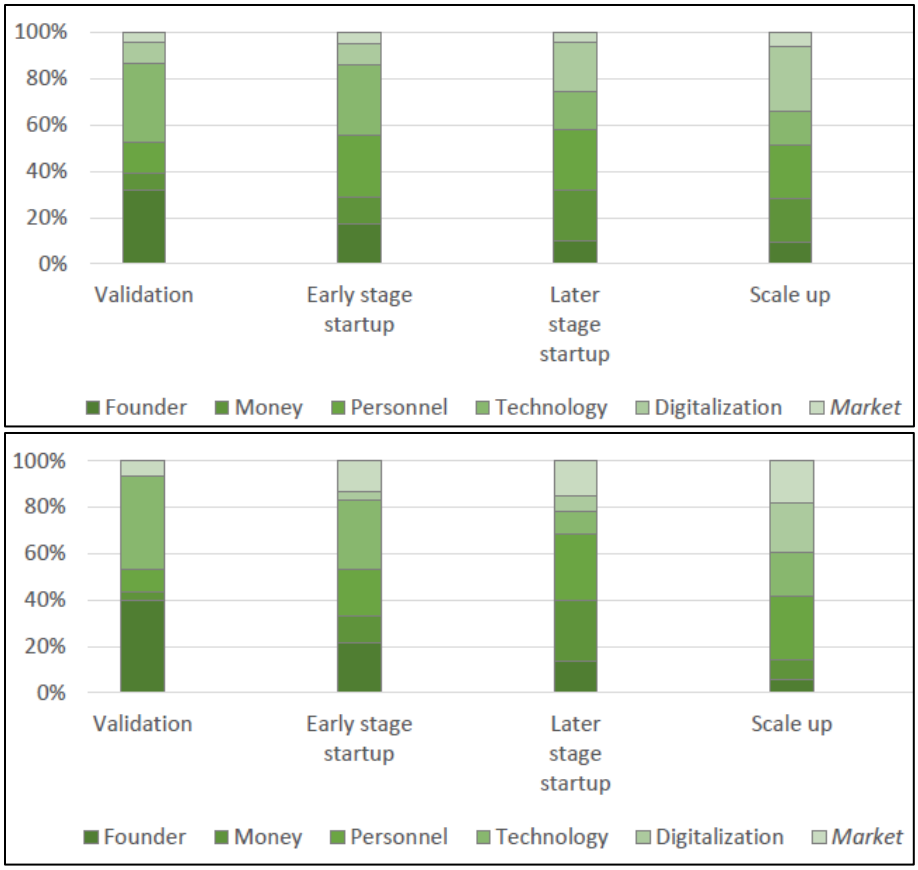


Figure 14 - Graphs with the average influence of every factor on the success of a startup (per stage) of group 1 (on top) & 2 (at the bottom)

The first thing that is noticeable between the two graphs in Figure 14, is that the startups in group 2 stated that digitalization has no influence on the success of their startup, compared to the startups in group 1 that stated that it has 9,6% influence already in the first phase. One startup in group 2 even stated that the influence of digitalization is 0 in the first two phases and another one stated that this is 0 in the first three phases. This is remarkable, since these startups stated during the interview that it is better to start earlier with digitalization rather than later. Looking at the further influence of digitalization in the graphs, both groups agree that the influence of digitalization rises over time.

"In the beginning it is still manageable, but when you go towards the scale up phase you need more help in the form of digitalization." (Interviewee-8, 2023)

"Digitalization is not important in the beginning. Digitalization starts to become important when you go into the scale up phase." (Interviewee-7, 2023).

Both groups have a similar view on the influence of the factors founder and money. The only difference with the influence of the founder is that group 2 thinks that this influence in the beginning starts higher and ends lower in the last phase. The same happens with the influence of money according to group 2, it starts lower in the first phase, peaks higher in the third phase and ends lower in the fourth phase.

The view of both groups on the influence of the other three factors during the lifecycle of a startup slightly varies. For the factor personnel, case nr. 1 believes that it rises in the beginning, stays constant in the second and third phase and then slightly decreases, while group nr. 2 believes that it rises in the first three phases and then will stay constant in the last phase. With the factor technology, both groups also have a slightly different view on the influence of this factor during the lifecycle of a startup. Group nr. 1 believes that the influence of technology starts with a significant influence in the first phase and then declines until the last phase. However, group nr. 2 believes that this influence starts out a bit higher, then declines as well (a bit more than at group nr. 1), but then rises again in the last phase.

The development of the influence of the market is quite different in both groups. During the lifecycle, group nr. 2 stated that the influence of the market starts low, but continues to rise until the last phase, while group nr. 1 stated that this influence will stay quite stable (and low) during the whole lifecycle.

5. Conclusion

This chapter contains the conclusions and will answer the sub-questions and the main research question of this research. Complementary to this, the conceptual model will be discussed, the contribution to the literature of this research and the practical contribution of this research.

5.1. Sub-question 1

SQ1. What are the obstacles that industrial startups in the Netherlands run into during the startup and transition phase?

Chapter 2.3.2 zoomed in on the obstacles that a startup runs into during the startup and transition phases by means of a literature review. The period of transition during which a startup grows up and becomes a scalable business is arguably the most critical time in the life of an emerging firm according to Picken (2017b). Combining the fact that 90% of all startups fail according to Krishna (2016), results in the fact that there are several obstacles during these phases. A literature review is performed on this particular topic, complemented with interviews with the investment director of YES!Delft and 8 industrial startups that are located in the Netherlands. This resulted in a number of different obstacles that are displayed in Table 7.

Table 7 – Different obstacles of a startup resulting from the literature review and the interviews with van Hall and the startups (the 1, 2 or 1&2 explain from which group this obstacle resulted)

Literature review	Interview van Hall	Interviews startups
Lack of funds	Lack of long term vision	Finding (new) people (1&2)
Lack of market need for the product (/sales and/or customer acquisition)	Producing everything in-house	Sales and/or customer acquisition (1&2)
Lack of experience	Go to the market too late and do not talk with customers	Cybersecurity (1)
Bad management	Cannot separate main and side issues	Lack of funds (1)
Premature scaling	Do not clear obstacles in the near future before they run into them	Big geographical distances (1)
Strong competition		Strict/heavy legislation (1)
		Developing the technology (1)
		Finding suitable (scalable) software programs (1)
		Maintaining high quality standards (2)
		Long negotiation times with (future) customers (2)
		Decision of widening/narrowing the product portfolio (2)

As displayed in the table above, there are a lot of different outcomes from the three methods however, there are two similarities between the literature review and the interviews with the startups; a lack of funds and difficulties with sales and/or customer acquisition. When looked at the literature review, these obstacles are the most common, but also very general obstacles compared to the obstacles that resulted from the interviews (which are more specific).

Another point that can be concluded from these obstacles is that the obstacles that resulted from group nr. 1 are more specific than the obstacles from group nr. 2. The reason for this, can be because these startups are less further in their lifecycle and are still focusing on more details and do not see the bigger picture (yet). Building on to this, the obstacles that the startups from group nr. 1 face are challenges that are more related to the development of their products, whereas the obstacles that the startups from group nr. 2 face are more challenges related to the process. This could be, because the startups in group nr. 1 are still developing and perfecting their product, compared to the startups from group nr. 2, where they are probably (almost) done with developing their product and shifted their focus on developing and perfecting the production process.

The obstacles that were stated by van Hall are also more focused on the obstacles that prevent investors from investing in these startups. A reason for this view of van Hall is possibly because his function at YES!Delft is focused more on the financial aspect of startups and making sure that these startups receive investments to continue the development of their product.

5.2. Sub-question 2

SQ2. How do startups evaluate their digitalization strategy?

Eight exploratory expert interviews are taken to answer this last sub-question. These interviews contained questions about digitalization (at their startup), the scaling up of their startup and it contained a conceptual model which is used to measure the influence that these startups think digitalization has on the success of their startup at every stage of their life (among other factors).

Out of these exploratory expert interviews resulted that all of these startups unanimously think that digitalization is very important to their startup however, only 3 startups could give some kind of definition about what digitalization actually is. Out of this (and the literature review) can be concluded that digitalization is a very comprehensive phenomenon. A possible explanation for this, is that the startups do not exactly know what digitalization is, which does not matter to them. They only want to use it, because it can result in more efficiency and time and money savings in their company. Even though the interviewer tried to get to know what the interviewees thought about when they used the term digitalization, all interviewees have a different view on what digitalization exactly entails.

A possible explanation for the fact that all these startups stated that digitalization is an important factor for the success of their startup could also result from the fact that these startups are technology focused. This could be different with startups in other sectors.

During the interviews the startups gave several examples of applications of digitalization. These applications of digitalization can be divided into three categories; optimization of the product, process

and organization. Another reason for the differentiation in evaluations of the digitalization strategy of every startup could be that they were all focusing on different categories of digitalization. A digital twin or simulation software is used for the optimization of the product, but an ERP or MES system is used to optimize the process and organization.

A number of applications are named by these startups to help them scaling up their company. Even though several startups stated that they would give as a recommendation to other startups to start as early as possible with digitalization, they all stated that digitalization is the least important in the first two phases of a startup. With the startups from group 2 even claiming a 0% influence on the success of a startup in the first phase (which is displayed in Figure 14). These results from the conceptual model are contradictory to what the same interviewees said during the interview. A reason for this can be that either these startups contradicted themselves, or that they used less advanced digitalization and did not interpret this as digitalization. It seems that all startups are using some form of digitalization but in many cases they do not recognize this as part of digitalization because it is seen as common sense or as standard for them. This makes interpretation of the answers difficult. A good definition is therefore needed for further research.

When asked if these startups have a digital roadmap, only two startups responded with yes. Which is remarkable as well, because even though all startups stated that digitalization is important to the success of their company (some even called it a *key success factor*) only a small percentage of them has a worked out plan for this.

When all this data is taken into consideration, it can be concluded that even though some startups claim that it is better to start as early as possible to apply digitalization at their startup and later contradict themselves by filling in the conceptual model, these startups are content with their digitalization strategy.

5.3. Main research question

Main RQ: How can digitalization help industrial startups to accelerate their innovations?

With the help of the sub-questions that are answered above, a better view is created about the influence of digitalization on the success of startups. Many applications of digitalization are named by the startups that helped their organization becoming more successful and to accelerate their innovations. These applications range from the more simple examples like online meetings and 3D modelling software, to the more advance examples like an ERP system, MES system, machine learning models and newly created API's.

Digitalization can help startups accelerate their innovation by creating and testing digital models instead of building and testing real life prototypes. This saves a lot of time, money and is also safer than performing tests in real-life (like the interviewee from startup 6 stated). It can help automate processes and let programs and machines communicate with each other, which can create smoother processes and higher quality products. Digitalization can also be beneficial for the after sales process, with (future) applications like predictive maintenance and remotely performed updates. Even though all startups see

digitalization as important, they use it in different ways as tools to support their overall objectives and challenges.

A lot of these applications of digitalization save a significant amount of time and money, because for example with predictive maintenance the startup does not need to send a maintenance engineer to the client out of the blue to fix a broken machine. With predictive maintenance the status of the machines can be monitored from the headquarters and maintenance can be carefully planned ahead. Remotely performed updates can also be planned and even performed without sending someone actually to the machine. This can all be done while staying at the headquarters of a startup.

Even though all startups are in favor of the trial and error approach, digitalization can help them to be more data driven. This can result in the startups to not just perform tasks without thinking, making mistakes and learning from them, but to be more data driven and create a more founded reason of why they perform some tests, or why they make certain decisions in their designs. If they are more actionable in a virtual environment, this can prevent a lot of mistakes and errors in a physical environment.

5.4. The conceptual model

During this research a conceptual model is created by the researcher to measure the influence of different variables (under which digitalization) on the success of a startup in four different stages in the beginning of the lifecycle of a startup. This conceptual model is based on literature reviews, validated by the investment director of YES!Delft and validated by eight startups after performing exploratory expert interviews.

This model resulted to be a valid model to measure the impact of these variables and is complemented with one other variable that influences the success of a startup resulting from the exploratory expert interviews, the variable *market*. This variable resulted to have a significant impact on the success of the startups and is added to make the conceptual model complete. The final version of the conceptual model is displayed below in Figure 15.

Dutch

Geef elke factor een weging m.b.t. de grootte, hoeveel deze factor bijdraagt aan het succes van uw bedrijf op het gegeven tijdstip.

English

Give every factor a weighing regarding the size, how much this factor contributes to the success of your company at the given times.

	Validation	Early stage startup	Later stage startup	Scale up
Founder				
Money				
Personnel				
Technology				
Digitalization				
Market				
Total	100(%)	100(%)	100(%)	100(%)

English

Founder	Passion, creativity, perseverance of the entrepreneur/founder
Money	External funding (+ revenue)
Personnel	The people in the organisation
Technology/product	Development of the break-through technology/product
Digitalization	Digitally capturing of products and process for the purpose of scaleability
Market	Market demand and the customers

Dutch

Oprichter	Gedrevenheid, creativiteit & doorzettingsvermogen van de ondernemer
Geld	Externe financiering (+ omzet)
Personeel	De mensen in de organisatie
Technologie/product	Ontwikkeling van doorbraaktechnologie/product
Digitalsering	Digitaal vastleggen van producten & processen t.b.v. schaalbaarheid
Markt	Markt-vraag en de klanten

Figure 15 - Final version of the conceptual model

Out of this model resulted that digitalization does influence the success of a startup, however it cannot solve all the problems that startups encounter and has a small influence compared to other variables.

5.5. Contribution to the literature

As stated in the first chapter of this research, similar research has been done in several other countries only, to the best of the researcher's knowledge, no research has been found on the impact of digitalization (on industrial startups) in the Netherlands. Especially for this research a conceptual model is designed by the researcher to measure the influence of digitalization in the first four phases of a startup. The contribution of this research to the existing literature is the testing of this conceptual model at industrial startups in the Dutch context. An additional contribution to the literature is a lifecycle model for startups that is designed during this research.

The results pointed out that digitalization can have an influence on the success of Dutch industrial startups, but that this is not the only factor that has to be taken into account. The conceptual model displays the six factors that all have an influence on the success of a startup. This conceptual model can be used in different sectors or different countries to see if the weight of the influence of these variables differs between other sectors or other countries.

5.6. Contribution to practice

The results of this research are directly applicable for startups as well as other companies. The conceptual model that is developed during this research can be used to create awareness among startups about the influence of digitalization in every phase of their lifecycle. This level of implementation of digitalization from different points in the lifecycle of a startup (small to no influence in the beginning, while the influence rises as the startup proceeds to the next phases), can be used as an example of how other startups deal with digitalization. This can be used as an example of which other startups can take knowledge from, if they are interested in this topic or considering to use digitalization for the benefit of their organization as well. Complementary to this, in this research a number of obstacles are discussed that startups run into in certain points in their life. In this research, startups can also read about some possible solutions for these obstacles.

Apart from this, companies that offer products that could help with digitalization solutions, can use this as orientation for the creation of digitalization solutions to help startups conquer their obstacles. They could also get a glimpse of the current level of digitalization at startups, when they feel the need to implement this and what kind of applications of digitalization are already on the market. As a result of this, companies could react to this with tailormade products & services for startups.

6. Discussion

During this research it became clear that digitalization can accelerate the innovations of industrial startups, but it is not the most important factor and cannot carry a startup on its own. There are several ways that digitalization can accelerate startups, but that is also while taking into account that all the other factors are of good quality as well. If a startup has a founder or management which takes bad decisions, then it will still be difficult to use digitalization to benefit the organization. Like the startups already stated in the interviews, digitalization is a tool to get somewhere and not a goal on itself. If a startup gets a tool like digitalization and does not know how to use it then it will still be difficult for it to be beneficial to the startup.

Some startups understand that sometimes they need to invest in software or (expensive) programs and systems to create a solid foundation to be able to grow in the future. However, this is a difficult decision in which you are investing significantly in digitalization in the beginning of your company to create a good foundation for the long run, but you still have to be able to grow your startup and make it for the long run. These significant investments in the beginning can also mean that a startup already starts with a big debt and an ascending pressure to succeed and pay back this debt.

This is a difficult decision to make and is not only good or bad. One startup from the second group even filled in that digitalization has had 0 influence on their success in the first three phases. They are in the scale up phase without using (a lot of) digitalization in their organization. However, they did use digitalization with (the development of) their product in an advanced way. This raises questions like is it possible to succeed without a significant amount of digitalization in the organization? Is digitalization to develop the product/technology more important than digitalization which is used to structure and develop an organization? They already reached the scale up phase without a significant influence of digitalization, do they not need digitalization at all or did they only push this obstacle forward and are they going to face this problem later on in the future?

It was interesting that especially the startups in group 2 stated that it is important to start as early as possible with digitalization and one startup even stated as something that they have learned, that they would have wanted to implement an ERP system earlier in their life. Contradicted to this statement, with the data they generated by filling in the conceptual model they all believed that digitalization did not have a big influence at all in the beginning of a startup. It could be that the kind of digitalization that they used in the beginning of their life is not seen as digitalization (anymore) per see by themselves.

6.1. Limitations

During the literature review certain search queries and a certain search engine is used for this research. Due to a limited amount of time, there was a limit on the number of search queries that can be used for this research. This could have resulted in the fact that some relevant articles are missed during this research. If more search queries are used and more search engines, this can result in more relevant articles and an even better foundation for the literature review part of this research.

The selection process to select startups that fitted in the scope of the project was a difficult process. The startups needed to be in the right sector, within the right geographical limitations and needed to be willingly and have time to participate in this research. Some startups were difficult to be contacted and some were not able to be reached at all. For the sake of time it was not possible to interview more startups to create a better generalizable study.

Exploratory expert interviews is the research method that is chosen for this research. This research method also has some limitations and other research methods could have brought other insights to light in this research. However for this situation this research method was the best option for this study to reach the most valuable results.

The skills of the interviewer were a limitation as well during this research, because the interviewer had very little training in this particular field. Apart from this, the interviewer resulted in creating an interesting data set with the interviews and applied a number of different tactics to make sure that the interviewees were as unbiased as possible.

6.2. Recommendations for further research

Further research in the phenomenon digitalization
Further research is needed to dive deeper into the phenomenon digitalization. Particularly on the different kinds of digitalization (like for example digitalization used during product development, for structuring the organization or smoothening the production process). After the interviews it became clear that even the startups that use digitalization in their own organizations do not know what exactly is digitalization and have different views on this topic. This also needs further research to zoom in more on the perception of what startups see as digitalization.

Further research in the contradiction of the statement to use digitalization in earlier stages
Moreover, it will be interesting to zoom in on the fact that a number of startups say that digitalization needs to be used in the earlier stages of their lifecycle, but then later on they contradict themselves with filling in the conceptual model of this research. Why is this contradiction among startups? Could it be that some more simple applications of digitalization, are not seen as digitalization anymore?

Further research in the influence of digitalization in other sectors
Another topic for further research can be the influence of digitalization at startups in other sectors. This research was focused on startups that find themselves in a technological sector which could result in a higher rate of the use of digitalization, because of the interest in technology itself. This could possibly be

completely different when startups from other sectors are interviewed that have less affection with technology.

Further research in the influence of digitalization in large corporations

The influence of digitalization should also be studied among larger corporations. It is possible that these larger organizations implement digitalization quicker, because they see the advantages that it has and they have a larger capital. On the other hand, it could also take longer for these larger organizations to implement these technologies, because of the large size of these organizations, the bureaucracy and the difficulties to implement new systems.

Reflection on MOT

This thesis is written to complete the study Management of Technology at the University of Technology Delft. The reflection of this research on the study of MOT will be done by assessing this research to the three criteria that would be considered to indicate a 'typical' MOT thesis.

The work reports on a scientific study in a technological context (e.g. technology and strategy, managing knowledge processes, research & product development management, innovation processes, entrepreneurship).

This research is performed on the influence of digitalization (technological context) on the success of startups (entrepreneurial context) in the manufacturing industry.

The work shows an understanding of technology as a corporate resource or is done from a corporate perspective.

This research is commissioned for Siemens. While performing this research, regular meetings were held with a company advisor (an employee from Siemens) to keep track of the corporate perspective. Complementary to this, this works shows an understanding of digitalization (as technology) as a corporate resource.

Students use scientific methods and techniques to analyze a problem as put forward in the MOT curriculum.

During this research several scientific methods (literature review, exploratory expert interviews) are used to analyze this problem.

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Appendix

A. Time schedule

The milestones of this master thesis are displayed in Table 8.

Table 8 - Milestones master thesis

Milestones	Week nr.	Date
Kick-off meeting	17	25-04-2023
Deadline to submit thesis	33	18-08-2023
Green light meeting	34	24-08-2023
Deadline to submit improved thesis	36	08-09-2023
Defense	38	21-09-2023

The time schedule of this master thesis is displayed in Table 9.

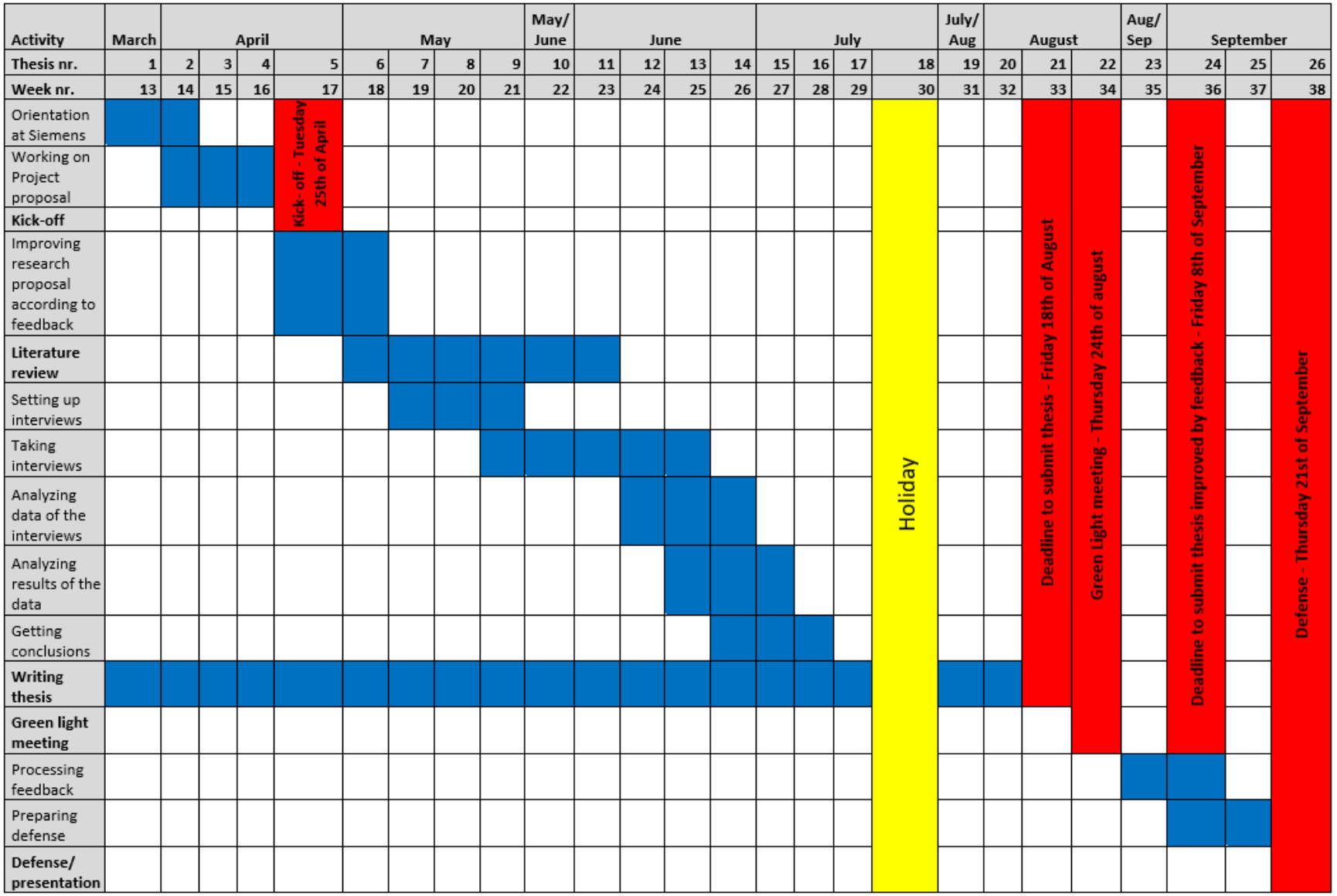

Table 9 - Time schedule of master thesis

B. Graduation Committee

The people who will supervise and assess me during this process are:

Chairperson & first supervisor: Dr. ing. V.E. Scholten

Organization: Delft University of Technology
Faculty: Technology, Policy & Management
Section:
Address:

Telephone:
E-mail:

Co-first supervisor: Dr. J. Gartner

Organization: Delft University of Technology
Faculty: Technology, Policy & Management
Section:
Address:

Telephone:
E-mail:

Second supervisor: Dr. A.C. Smit

Organization: Delft University of Technology
Faculty: Technology, Policy & Management
Section:
Address:

Telephone:
E-mail:

External supervisor: Ir. D. Kofman

Organization: Siemens
Department: Business Accelerator Team
Function: Education Xcelerator
Address:

Telephone:
E-mail:

C. Informed consent form

Research:

Master:	Management of Technology
Faculty:	Technology, Policy and Management
University:	University of Technology Delft

Name researcher:
Robin van Dijk

Goal of the research:
This master's thesis aims to investigate the influence of digitalization on the startup process, with a specific focus on scaling up from startup to scale-up. The goal of this research is to examine whether (and how) digitalization can have a positive impact on the speed and degree of success in the scaling up of a startup.

Your cooperation:
By signing this document, you indicate your consent to participate in this research. Even after signing, you can still choose to withdraw your participation. Your participation, however, is greatly appreciated!

The data for this research will be collected through interviews, which will be handled and stored carefully on my personal OneDrive (where I am the only one with access). This means that the data will be processed anonymously, and no one will be described in the final report in a way that is recognizable by third parties. During the interview, you always have the option to decline to answer a question, take a break, or stop the interview. If desired (see below), I can also provide you with the final research report or its summary.

I hereby give consent to participate in this research,

Name: ……

Address: ……

City: ……

Signature: City: ……

Date: ……

Please check the applicable option below:

□ I would like to receive the complete report.
□ I would like to receive the summary of the report.
□ I do not need to receive anything about the research afterwards.

If you have checked one of the boxes: how would you like to receive the document?

□ By mail, to the following address: ……
□ By email, to the following email address: ……

D. Interview Jan Geert van Hall

Interview questions Jan Geert van Hall

1. Introduction
2. Recording

*Doing an introduction talk and tell about my research. The **goal of my research*** is to find out if (and how) digitalization can accelerate and have a positive influence on the success of the scaling process of a business.

Introduction

- What is your function?
    - And how long are you already doing this?
- How and why did you went to work at YES!Delft?
- Why the interest in this discipline?
- What does your own startup *BlueBots* entail?

The scaling up of startups:

- What are, according to you, the stages of the lifecycle of a startup?
- What are the most common obstacles faced by startups in the scaling-up phase?
- How do startups deal with these obstacles?
    - How do startups conquer these obstacles?
    - What are the most common mistakes that startups make at these moments?
- What are things that are going well for startups in the scaling-up phase?
    - Or in which elements do you see that there is a lot of room for improvement?

Digitalization

- What do you think is (industrial) digitalization?
- How do you think digitalization can support the scaling-up process of startups?
    - Or what elements of digitalization could startups use?

Conceptual model

- What are the variables/factors that influence the success of (the scaling-up of) a startup?
- Here is my conceptual model, what do you think about this model?
    - Do you have any additional input or comments on this model?

Closing:

- Is there anything else I forgot to ask or anything you would like to add?

Conceptual model

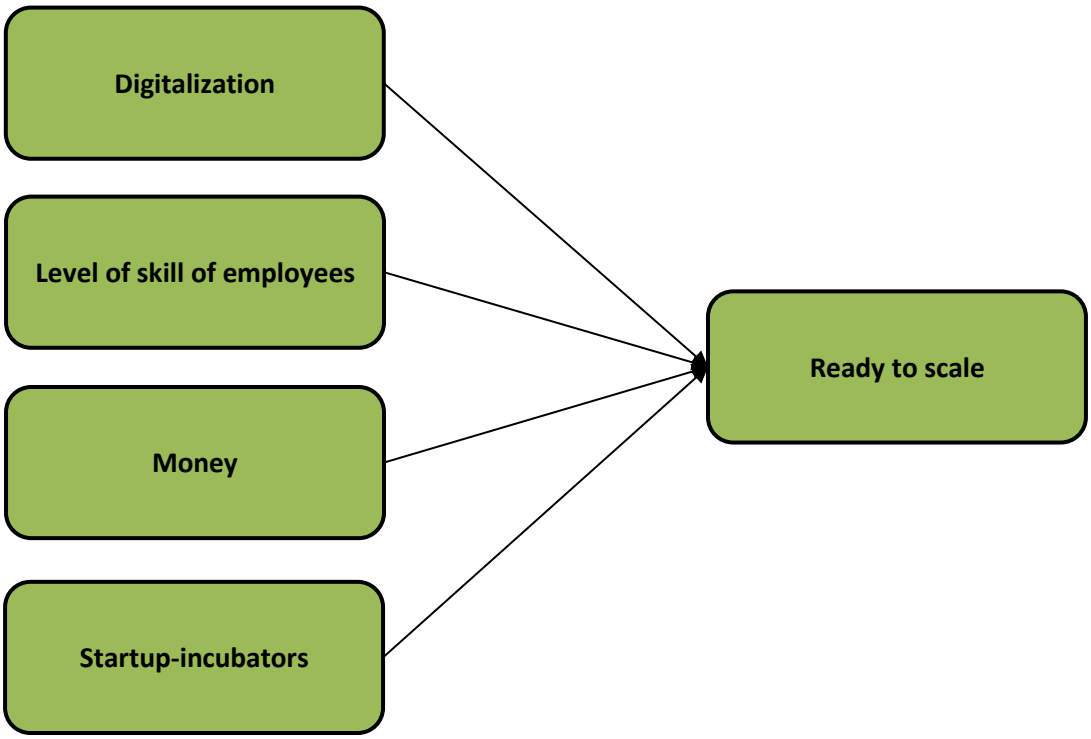

Figure 16 - Conceptual model (first version)

E. Interview questions startups

1. Introduction
2. Anonymity/informed consent form
3. Recording

*Doing an introduction talk and tell about my research. The **goal of my research*** is to find out if (and how) digitalization can accelerate and have a positive influence on the success of the scaling process of a business.

Introduction

- What exactly is it that your company does and what makes your company unique?
- What is your function?
    - And how long are you already doing this?
- How and why did you went to work at *[name of the company]*?

These days, more and more is digitalized and more work is executed on a digital level. Digitalization, (sometimes also known as industry 4.0) is an upcoming trend.

Digitalization

- What do you think is (industrial) digitalization?
- How important is digitalization in your company? (why is important/or not?)
- How do you think that digitalization can support your scaling up process? (or which elements of digitalization do you think that you can use?)
- Do you have any concrete examples of digitalization in your company?
    - If yes, in which applications are you implementing it?
    - If no, why haven't you implemented it?
- Do you have a digital roadmap/plan for the future to adopt digitalization or further expand it in your company?

If the prototypes are successful and the product is nearly complete, the logical next step is to scale up (the production capacity).

Scaling up:

- What are currently the biggest challenges in scaling up your company?
- How do you plan to address these challenges?
    - What is the most important thing you have learned so far?
    - What would you have done differently in hindsight?
- What are your biggest successes (in scaling up)?
    - What tips would you like to share with other entrepreneurs/companies?

During my research, I have created two models:

- *The first model allows me to categorize companies based on the phase they are in.*
- *The second model helps me understand which variables companies consider important and how significant they believe these variables to be.*

Conceptual Model:

- What are the variables/factors that influence (the scaling of) your company?
- Here is my conceptual model, to what extent does it align with your company?
- Would you like to fill in my conceptual model with the values you think are applicable?
- Do you have any additional input or comments on this model?

Closing:

- Is there anything else I forgot to ask or anything you would like to add?

F. Conceptual models filled in by startups

Group 1 – Conceptual models filled in by startups

	Validation	Early stage startup	Later stage startup	Scale up
Founder	15	10	10	5
Money	5	10	10	5
Personnel	15	20	20	25
Technology	60	40	30	30
Digitalization	5	20	30	35
...	*0*	*0*	*0*	*0*
Total	100	100	100	100

Figure 17 - Conceptual model filled in by startup nr. 1

	Validation	Early stage startup	Later stage startup	Scale up
Founder	40	30	20	20
Money	2	4	25	25
Personnel	18	20	20	20
Technology	25	40	10	10
Digitalization	15	6	25	25
...	*0*	*0*	*0*	*0*
Total	100	100	100	100

Figure 18 - Conceptual model filled in by startup nr. 3

	Validation	Early stage startup	Later stage startup	Scale up
Founder	40	20	0	0
Money	0	0	30	10
Personnel	0	30	30	30
Technology	40	25	0	0
Digitalization	0	0	20	30
Client/Market	*20*	*25*	*20*	*30*
Total	100	100	100	100

Figure 19 - Conceptual model filled in by startup nr. 4

	Validation	Early stage startup	Later stage startup	Scale up
Founder	33	5	5	5
Money	10	20	20	35
Personnel	5	33	30	10
Technology	33	31	22,5	20
Digitalization	18	10	22,5	30
...	*0*	*0*	*0*	*0*
Total	100	100	100	100

Figure 20 - Conceptual model filled in by startup nr. 6

	Validation	Early stage startup	Later stage startup	Scale up
Founder	30	20	15	15
Money	20	25	25	20
Personnel	30	30	30	30
Technology	10	15	20	15
Digitalization	10	10	10	20
...	*0*	*0*	*0*	*0*
Total	100	100	100	100

Figure 21 - Conceptual model filled in by startup nr. 8

	Validation	Early stage startup	Later stage startup	Scale up
Founder	31,6	17	10	9
Money	7,4	11,8	22	19
Personnel	13,6	26,6	26	23
Technology	33,6	30,2	16,5	15
Digitalization	9,6	9,2	21,5	28
Market	*4*	*5*	*4*	*6*
Total	100	100	100	100

Figure 22 - Conceptual model with the average values of group 1

Group 2 – Conceptual models filled in by startups

	Validation	Early stage startup	Later stage startup	Scale up
Founder	30	15	10	5
Money	0	15	20	10
Personnel	30	30	30	20
Technology	30	30	20	15
Digitalization	0	0	0	20
Market	*10*	*10*	*20*	*30*
Total	100	100	100	100

Figure 23 - Conceptual model filled in by startup nr. 2

	Validation	Early stage startup	Later stage startup	Scale up
Founder	20	20	10	0
Money	10	20	40	10
Personnel	0	10	30	40
Technology	70	40	10	30
Digitalization	0	10	10	20
...	*0*	*0*	*0*	*0*
Total	100	100	100	100

Figure 24 - Conceptual model filled in by startup nr. 5

	Validation	Early stage startup	Later stage startup	Scale up
Founder	70	30	20	12
Money	0	0	20	6
Personnel	0	20	25	22
Technology	20	20	0	12
Digitalization	0	0	10	23
Market	*10*	*30*	*25*	*25*
Total	100	100	100	100

Figure 25 - Conceptual model filled in by startup nr. 7

	Validation	Early stage startup	Later stage startup	Scale up
Founder	40,0	21,7	13,3	5,7
Money	3,3	11,7	26,7	8,7
Personnel	10,0	20,0	28,3	27,3
Technology	40,0	30,0	10,0	19,0
Digitalization	0,0	3,3	6,7	21,0
Market	*6,7*	*13,3*	*15,0*	*18,3*
Total	100	100	100	100

Figure 26 - Conceptual model with the average values of group 2

Conceptual model with the average value of both group 1 & 2

	Validation	Early stage startup	Later stage startup	Scale up
Founder	34,8	18,8	11,3	7,8
Money	5,9	11,8	23,8	15,1
Personnel	12,3	24,1	26,9	24,6
Technology	36,0	30,1	14,1	16,5
Digitalization	6,0	7,0	15,9	25,4
Market	*5,0*	*8,1*	*8,1*	*10,6*
Total	100	100	100	100

Figure 27 - Conceptual model with the average values of both group 1 & group 2