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Exploring business change: The design of a digital tooling for business model exploration for the automotive ecosystem

Proefschrift

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op gezag van de Rector Magnificus, Prof.dr.ir. T.H.J.J. van der Hagen,
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op
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Door

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The photo of the cover is courtesy of Maria and Antonia Tsirigkouli. This photo was taken in the mid-60s in the Greek city of Patras. In the photo, the owner of a small jewelry shop, Katerina Tsirigkouli, the local reseller of the Omega watches (Omega is a luxury watchmaker company) in Greece, a Swiss representative of the company, and two women window shopping can be seen. This photo illustrates how the business operated based on the traditional business model of the seller buying a product for an X price and selling to their customers for X+Y. The rest of this thesis focuses on new business models where technology complicates the business model structure and business model exploration is needed.

To all the brave and fearless women of the past that fought for equal education for the women of the present and the future.

To all the dyslexic minds, who sees letters dancing between the lines. Life is nicer when dancing.

Για την οικογένεια μου

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Emrah μου, thank you for entering and being in my life. We met when you were writing your Ph.D. thesis, and now I have finished mine. We were crazy enough to not give up on us while living on opposite sides of the world, but it was the best decision ever. For all the memories we have together, all the memories we will create together, for all the continents, countries, cities, and airports we met in for a few days or a few hours, for all the late-night/early-morning Skype calls we had, the middle of the night texts, you have my unconditional love and support. And as Nâzım Hikmet says*: *En güzel deniz, henüz gidilmemiş olanıdır, En güzel çocuk, henüz büyümedi. En güzel günlerimiz henüz yaşamadiklarımız,ve sana söylemek istedigim en güzel söz, henüz söylememiş olduğum söuzdu.* [1]

My cute ones, *Χρυσάνθη, Αναστασία και Χρήστο*, I am sorry that I was away but you know that your aunt is always a text, a call, or a flight away. Είσαστε το μεγαλύτερο κίνητρο για όλα, *...zia Alexia vi ama molto!*

Alexia Athanasopoulou
October 15, 2019

[1] En güzel deniz by Nâzım Hikmet: *The most beautiful sea hasn't been crossed yet. The most beautiful child hasn't grown up yet. Our most beautiful days, we haven't seen yet. And the most beautiful words I wanted to tell you I haven't said yet....* Follow the link for the melodized greek version. Lyrics by Yiannis Ritsos, and vocals by Manos Loizos `https://www.youtube.com/watch?v=86zl4oPzPpU`.

Contents

List of Abbreviations

AI	Artificial Intelligence
BMI	Business Model Innovation
DSR	Design Science Research
ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technology
OEM	Original Equipment Manufacturer
SME	Small and Medium Enterprise

Chapter 1

Introduction [1]

‘Αρχή ήμισυ παντός.’
-Πλάτωνας, Νόμοι [2]

[1]This chapter is based on: Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) Tool for Internet-of-Things business model exploration: A Design Science Research Approach In ECIS 2018, Portsmouth, UK., and Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) Designing digital tooling for business model exploration for the Internet-of-Things. In Desrist 2018, Chanai, India

[2]The beginning is half of the whole.’
Plato, Laws

1.1 Background

Digital technologies are fundamentally transforming businesses [31], their offerings, their operations, the involved stakeholders, and therefore their business model. Regarding enterprises, technologies are able, not only to digitalize services but also to transform services to something significantly improved. Only in 2017 enterprises invested 1.14 trillion euro on digital transformation technologies with that amount is expected to expand 1.85 trillion in 2021 [9]. Digitalization can affect in many ways any enterprise of any size, in any type of industry, and company.

There are different industries that are affected by new technologies. For instance, in retail, e-commerce marketplaces are evolving into multi-sided experience platforms. In the media industry, algorithms from social media companies like Facebook lead news companies to focus on maximizing views. In the logistics industry, parcel companies use Artificial Intelligence (AI), and Big Data to improve their decisions making, to optimize processes, improve their worldwide delivery network, and their customer services. In the retailing industry, enterprises use technologies to improve customer services by, for instance, using barcodes for faster check out payment, or webshops where customers can shop their groceries from the convenience of their home. Finally, in the automotive industry, manufacturers use AI, data analytics and machine learning with main purpose to create new services, and shifting from selling the engines to offering 'power per hour' services to its customers, or by offering end to end solutions to the customers, such as electric batteries, solar storage, and charging points.

From the examples above, we can see that enterprises in different industries use different digital technologies for various purposes, and with different outcomes, such as new services, different revenue models, or channels. What is evident and common on the above examples is that digital technologies 'contribute' to business transformation, and therefore the emergence of new business models such as the 'end to end' business model of Tesla company. As a consequence of novel digitally enabled services and products, business models are changing as well as [159]. General, when environments change, companies need to reinvent or reconsider existing business models to stay competitive ([68], [203]). One instance of such an environmental change is disruptive technologies, which necessitate enterprises to redesign their business models [68]. Examples of digital technologies that serve as disruptive technologies requiring new business models are social media, cloud computing, and the Internet of Things (IoT), which are typically captured under the umbrella term of digital transformation.

Social media (e.g., Twitter, Facebook, Instagram) are platforms that allow the easy access of information, sharing of content, facilitates discussions and participation, and user-generated content through social networking, wikis, and blogs. Social media can change business models. For instance, YouTube is based on content generated by the end-users who serve as content creators, producers, and consumers. YouTube reshaped business model with changes in value offering, organizational design, and revenue models. Additionally, social media transforms the way enterprises market their offerings. Enterprises easier can reach beyond their boundaries, and to collaborate with third parties.

Cloud computing enables on-demand, and ubiquitous network access to shared computing resources such as servers, networks, applications) to its users, that can be developed and offered with minimal efforts from the managers and the interaction with the service providers. Cloud computing allows customers to access and process data storage via the internet. In cases that cloud computing is not used, enterprises had to buy the needed hardware and software. Cloud computing enables 'pay-as-you-go' business models with enterprises accessing specific hardware and software only when needed. Another change that cloud computing enables the business models is the remote work. Remote work can change the organizational design of a company as well their customer relationship as it makes it easier for customers to reach customer support.

The Internet of Things (IoT), is expected to affect enterprises in many industry sector [138]. An increasing number of physical and digital objects -over 10 billion are connected and sharing information with each other. As a result, the physical world is becoming interconnected with the digital world composing the IoT [230]. IoT can improve customer experiences, supports faster handling, increases cost efficiency, and process agility [214], and improves forecasting of stock situations [98]. Mobility oriented enterprises like TomTom, or Uber take advantage of digital technologies by providing new digital products and services (e.g., smartwatch, navigation apps).

The aforementioned cloud computing, social media, and IoT are only a few examples of digital technologies reshaping business models. They illustrate that technologies are emerging and evolving, new services are released, new ways of offering services are available, new organizational designs, and customer relationships are emerging and together indicate the need for the development of new business models.

An example, (and our focus) of an industry that digital technologies change the business models in the automotive industry. The automotive industry that offers mobility services, traditionally depending on physical objects, is adapting to new digital opportunities. Traditionally non-digital enterprises (e.g., gas stations, taxi drivers) shift to a digital environment in order to increase their value ([89], [138]). Transportation services *'no longer meet the growing diversity of consumers'* needs for [...] digitally enhanced mobility experiences' [185] p.2). While the basic product –the car- cannot turn from physical to digital completely [185], *'the future car has been described as a sit-in mobile device'* ([119] p.97). Dombrowski and Engel [76] argue that the automotive industry is facing *'an unprecedented change'* (p.1) that will affect the automotive industry and the way people live their lives. [76]. Furthermore, the 'boundaries' of the automotive industry, including initial car manufactures, are expanding. More actors are taking part like automotive suppliers, infrastructure suppliers, services products and aftersales providers [151], and many more enterprises can offer services and products related to mobility apart from the manufacturers [90]. In other words, the automotive industry's boundaries are becoming more fluid, and more enterprises that offer mobility services entering the market. However, there is still not much knowledge of the challenges that enterprises within the automotive industry are facing due to digital technologies [185]. Nevertheless, considering the potential, it is important for organizations within the automotive industry to rethink their business models.

Digital technologies are transforming business models in ways that we have not seen before. Digitalization goes beyond merely automating existing processes and making them more efficient. Digitalization implies fundamentally new ways of creating and capturing value. While there is consensus on this premise, how to approach the challenge of changing a business model because of new-to-the-world technologies cannot rely on existing recipes.

Based on the above, we describe the practical problem as:
Digital technologies are changing business models. Due to digital technologies, enterprises are moving, for instance, from selling physical products to providing digital-enabled services. Focusing on the automotive

industry and the changes in their mobility products and services (e.g., connected cars, e-mobility, supporting apps) digital technologies require enterprises to rethink their business model. Enterprises will need to innovate and adapt their business model to take part in a technology-enabled automotive industry. However, how to adapt and apply existing business models is not always obvious.

1.2 Scientific problem

After the emergence of the Internet, and related digital technologies, the interest on business models increased ([19],[66], [12], [233], [238]). Business models are considered essential for experienced and establishing organizations [150], as they contribute to competitiveness [70] and help commercialize relevant offerings (products and services). Business models describe how a company creates, delivers and captures value [17], and how value is derived from technological innovation [59]. While there is a considerably broad array of literature on business models comprising different schools of thought (see for an overview [233]), few conceptualizations make an explicit link between technological innovation and business models [39].

In times of change, enablers allow the creation of business opportunities making valuable for organizations to rethink their business models to stay competitive and profitable [48]. Examples of enablers are the enterprise's innovative use of resources, poor performance, or disruptive technologies [68]. Based on the identified practical problem we previously discussed, we will explicitly focus on disruptive technologies as enablers. Focusing on business models, scholars mainly discuss established organizations that have to innovate their existing business model due to a new market (e.g., [139]) or due to uncertainty [204], but specific digital disruptions (e.g., cloud computing, IoT) as enablers for new business models are less discussed.

The process of redesigning business models is called Business Model Innovation (BMI). BMI refers to the ways organizations change their business logic while an idea is created, analyzed, tested and implemented in parallel with innovation [116]. Given the many unknowns in adapting business models to disruptive digital technologies, often extensive business model exploration is required.

Business model exploration is the iterative process through which new business model ideas are created, conceptualized, and tested until a revised, alternated, and assumed a viable business model is reached.

With business model exploration, enterprises can discover new business model opportunities [67]. A systematic approach to business model exploration enables enterprises to obtain new (or revised) business model ideas ([20] [161]) and creative competitive advantage ([82], [203]). However, literature is scarce on what activities are undertaken during business model exploration, and how technology disruptions enable business model exploration.

In many publications, the process towards designing a business model is presented as a linear process, while in practice, business managers face the uncertainty of the evolving markets that cause loose processes [30]. Business model exploration can be important when new opportunities require the rethinking of the business model. Business model exploration involves creating alternative business models, and suggesting changes [52], conceptualizing the changes, conceptualizing these business models [203], and assessing what could happen under a range of different alternatives [34]. Sosna et al. argue that most business models have not *'gone straight from the drawing board into the implementation [...] in reality new business models rarely work the first time around since decision-makers face difficulties in both exploratory and implementation stages'* ([203], p. 384). What Sosna et al., argues is that enterprises go directly from designing a business to implementing it, and in many cases that is unsuccessful, because of the involved individual faces difficulties with business model exploration (idem). For this study, we focus on business model exploration triggered by technology disruption. We are interested in investigating how business model exploration is held in practice and identifying the activities that are undertaken during the business model exploration. Scholars and practitioners point out that is necessary for the development of practical tools and approaches to support BMI [100].

BMI is considered a creative task, as it relies on the idea generation. Research in varius fields (e.g., progress modeling, creativity support systems, new product development field) that are creative in nature can benefit from the support of tools [208]. Business model tooling can be used during the business model explorations as they can support the development of alternative business models. Scholars and practitioners are interested in developing a new business model tooling to contribute to the business model innovation process. However, the benefits of business model tooling are still not sufficient studied [82].

Within the business model literature and practice, different tools related to business model can be found. Business model tools are available in different formats, and factions. Regarding the formats, the business model Canvas [179] is available in many forms such as book, web-based app (e.g. [2]) and mobile app (e.g. Business Model Canvas and SWOT). Other tooling formats are printed cards (e.g. [95]), computer-based (e.g. [113], [68]) or web-based (e.g. [1]). Regarding the functions, existing business model tools allow to *'represent, share, annotate and version business models'* [208].

Based on the functionalities, these business model tools can be categorized based on their purposes such as tooling to explore new business model opportunities, to design new business models, to test business model testing, tooling to support business model implementation or tooling that supports business model growth [67]. Business model tools that are developed for business model design, testing, and implementation are emerging. Existing tooling is mainly developed for designing business models (e.g., [179], [39], [22]). Supporting tools for systematic business model exploration are lacking, in particular in relation to disruptive technology ([39], [186], [191], [138], [79]).

Domain-specific business model is a topic of the literature such as [140] who focus specifically on the domain of electric mobility and the business model adopted in this domain. Unlucky the publications that identify the business model for specific domains, academics and practitioners do not specifically develop business model tools for specific domains. Existing tooling is often generic without considering a specific digital technology innovation or domain industry. That can be a problem as the generic tools might overlook details related to specific technologies and industries. Therefore, domain-specific business model tooling can be a potential solution. The question that arises is: *'what is a suitable domain to develop such tooling for, and most likely to need business models exploration?'*. To understand the problem we will focus on a specific industry (i.e. automotive industry) and one specific major disruption (Internet of Things). We focus on a specific domain as we want to design and develop a domain-specific tooling, and that requires to identify and analyze a specific domain. While generalizability is important for any study, the focus is needed to make this specific research possible. Inevitably, that leads to some limitations when it comes to generalizability (generalizability and limitations will be discussed in chapter 8). The outcome of our research will be a business model tooling infuenced by the automotive industry and the IoT (domain-specific). However, we want to create an artifact that is possible to be used by users outside the automotive industry too, and for that reason, our research questions will not be focused on the automotive industry.

In sum, we identify the below gaps in the literature:

- Existing business model tooling is mainly focused on formalizing one specific business model design rather than facilitating systematic exploration of alternative business models.
- Existing business model tooling does not pay attention to the new technologies, how they affect the business models, and how they can be taken into account at the development of business model tools.
- There is a lack of domain-specific business model tooling that takes into consideration the technology disrupted specific domains.
- There is a lack of understanding of the role of domain-specific tooling in business model exploration.
- There is not clear evidence of the usefulness of business model tooling functionalities.
- There is not a clear indication if business model tooling contributes to the exploration of new business models from an existing one.
- It is unclear what activities are undertaken during business model exploration.

Based on the above, the scientific problem can be shaped as such:
Technology disruption enables (and requires) changes in the business models. What can be changed is not always obvious, and business model exploration is needed. However, there is a lack of research on the business model exploration, especially in the case of specific domains. A way to support the business model exploration is with the use of business model tools. Though, there is a lack of research on how domain-specific business mode exploration can be. Finally, there is a lack of knowledge on how these tools contribute to the business model exploration for disruptive digital technologies.

1.3 Research objective and research questions

Based on the literature gaps identified in the previous section, the objective of this study is as follows.

The objective of this study is to design tooling to support business model exploration.

Five research sub-questions (RQx) have been identified.

What can we learn from exploring the existing business model tooling? (RQ1)

The first research question covers the review of the relevant literature. The literature review will inform the design decisions regarding the tooling. During this step, we will review the literature of the business models, business model innovation (BMI), and we will investigate the literature regarding the business model exploration, what it includes and how it can be supported. Lastly, we will review the existing business model tools available in the literature and in practice, and identify patterns in the functionalities of tools, and identify if existing artifact can support business model exploration. The literature review is presented in Chapter 3.

What activities are undertaken during business model exploration? (RQ2)

After understanding the related literature and the description of the domain, we need to describe the activities that are undertaken during the business model exploration, and to identify and create a set of design principles for the designing tooling extracted from an empirical study. We discuss this study in Chapter 5.

What are the design requirements for designing tooling that supports the business model exploration activities? (RQ3)

During the same empirical study, we will identify the design principles. The design principles will inform the functional requirements for the prototype to be developed. In Chapter 5 we will present and discuss the empirical research we undertook that informs the design of the prototype.

What functionalities can support business model exploration? (RQ4)

The purpose of this research question is to translate the design principles to functionalities and finally working tooling. To do so, we need to identify, describe and implement functional and non-functional requirements. Qualitative analysis will support this step and provide answers to this question. Chapter 6 presents the research and an overview of the working prototype.

What are the effects of the developed tooling on the business model exploration process as identified in theory and practice? (RQ5)

The focus of the last research question (RQ5) is the evaluation of the developed tooling. The evaluation will indicate to which extent the developed digital artifact supports business model exploration process. The evaluation of the prototype validates its functionalities regarding business model tooling for business model exploration. In Chapter 7 we will provide a detailed description of the evaluation, and the results.

We use the automotive industry as our domain of research. Our mission is to show the impact of domain-specific tooling on the process of business model exploration. This requires a domain. Therefore, the role of the automotive industry is instrumental.

We first review how the industry into transforming to an ecosystem with flexible boundaries. We aim to understand what the changes are, how the changes affect the business models. Empirical research will support this part of our study. The results are presented at Chapter 4.

1.4 Expected Contributions and Research Methodolgy

This study will deliver an artifact (i.e., the digital business model tooling) that gives answers to unsolved problems (i.e., business model exploration after technology disruption) and thus, a Design Science Research (DSR) [121], [184], [223]) is followed as a research approach. Following the DSR approach, and answering the sub-questions, we aim to contribute to the business model literature with the set of functionalities and variables for investigating the theory related to business model exploration. More specifically, this research will allow us to provide design guidelines for the development of business model exploration tooling. The study will contribute to the business model literature by providing more insight regarding business models exploration. This study aims to contribute to the business model tooling literature on what concepts can contribute to the business model exploration. Additionally, we aim to contribute to the theory of business models by investigating how, and if domain-specific business model tooling contributes to business model exploration processes enabled by digital technologies. In general, with our research, we aim to contribute to a better understanding of the BMI, by investigating what business model tooling functionalities can support users with BMI.

Research that derives design relevant knowledge for business model tooling is needed, as there is no evidence of the usefulness od specific business model functionalities [208]. Gregor classifies five types of theory related to IS: '(a)*Analysis*: The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made; (b) *Explanation*: The theory provides explanations but does not aim to predict with any precision. There are no testable propositions; (c) *Prediction*: The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations; (d) *Explanation and Prediction*: Provides predictions and has both testable propositions and causal explanations; (e) *Design and Action*: The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact' ([110] p.620).

Our research aims to contribute to the fifth type of theory, namely *design and action*. This type of theory indicates how to do something. The 'how' can take the form of methods, justificatory theoretical knowledge, or principles of form and function (idem). In our research, the 'how' will take the form of the functionalities of the novel artifact to be developed. These functionalities will be then tested with potential users for its effectiveness. Reflecting upon these evaluation results we will discuss the final contributions (in Chapter 8).

One more point regarding the research contribution is the level that a DSR study can make. Gregor and Hevner argue that in practice nothing is 'new' and the level of contribution of a DSR depends 'on its starting points in terms of problem maturity and solution maturity' ([111], p2.344). Regarding the maturity levels, and the potential contributions there are four different types of research: (a) Routine Design (low maturity solution, low application solution, no knowledge contribution): In this case, the problem is well understood and existing tooling is created to address this problem. In this case (usually) there is no contribution as existing knowledge is applied to known problems. (b) Improvement (low maturity solution, high application solution, knowledge contribution): This type of research creates better solutions for a known domain. In this case, the researcher creates a new solution in the form of innovative tooling. The challenging aspect of this research is to demonstrate that the newly created solution is an improved solution advanced to previous knowledge. (c) Exaptation (high maturity solution, low application solution, knowledge contribution): In this case, effective tooling existing in similar application domains is applied to the domain of interest. For this new application domain, the research needs to demonstrate that the extension of the existing knowledge to that domain is interesting. This type of research can produce new knowledge related to the effectiveness of existing design to new domains. (d) Invention (high maturity solution, high application solution, knowledge contribution): In this type of research, the result is a new artifact for a domain of low maturity that can be applied an evaluated in a real-life setting, and contribute to the knowledge base. This type of research investigates domains with limited current understanding and with no known effective tooling available [111].

Our research investigates the domain of business model exploration where limited research is available (domain maturity low). Additionally, we aim to create a new artifact that is a domain-specific business model tool (solution maturity low) for business model exploration. Then, this artifact will be tested and evaluated in real-life settings for its effectiveness. Based on the evaluation we will discuss the contribution to the knowledge base. Therefore, our study fits the Invention type of research as we will create a new solution for a domain that is not well investigated.

Figure 1.1 . presents the 2×2 matrix of our study maturity, pointing out the level of maturity and the potential DSR contribution of our study. The x-axis represents our application domain that is the business model exploration, while the y-axis represents our solution that is domain-specific business models.

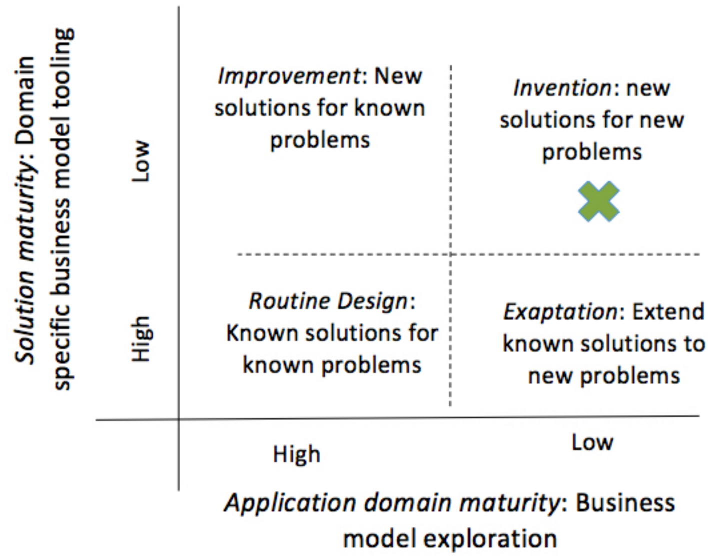

Figure 1.1
Positioning of the study regarding the level of maturity. Adopted from [111]

1.5 Thesis Outline

The chapters of this thesis are structured as followed.

In chapter 2, we discuss the research approach we followed for this study. First, we present the methodology to achieve our overall aim. A Design Science Research (DSR) methodology is used as the main research approach of the study. We present the literature related to DSR, and the relevance of design as a scientific method. Finally, we discuss the DSR literature, and how we implemented it for this thesis.

In chapter 3 we discuss the literature. We review the theories of business models and business model innovation process (design, experimentation, implementation. Additionally, we focus on the business model innovation process. Furthermore, we focus on the business model tooling literature as the aim of this study is to create a tool for the previously identified problem. We first present the existing tools developed by academics and practitioners and we identify what is available and what is missing.

In chapter 4, we discuss the automotive industry as the focal domain for our research and one prominent technology disruption. As far as the automotive industry it concerns, it is discussed as an industry that disruptive technologies and more specific the IoT, have already changed the way the automotive ecosystem is (e.g., new actors, new products, the car as an add on platform.

In chapter 5, we discuss the study that allowed us to identify the design principles based on the assumptions we made in the previous chapters. Action research is used as the method that will allow us to collect empirical data. From these empirical data and literature review, we identify and present a set of design principles for the design of the artifact for business model exploration.

In chapter 6, we discuss the development of the tool. We start the discussion with the non-functional requirements as they were extracted from a secondary analysis of interviews on generic requirements on how business models should be. We continue with a network analysis that will allow us to identify what elements or functionalities are needed to be included in the prototype of the artifact. We will conclude with the presentation of the working prototype.

In chapter 7, we discuss the evaluation methodology that is an experimental design approach. The experimental design will take place in two phases (for improvements). First, we discuss the first cycle iteration the preliminary results and our actions towards a revised version of the artifact. Next, we present and discuss the questionnaires, and the measurements, control variables, the validity, and independent variables, and the collected data from the data analysis.

In chapter 8, we reflect upon the results. Firstly, we discuss our findings related to the design principles. Next, we discuss the limitations and future research. Final remarks, reflections, and recommendations from the research will be discussed in the last section of this chapter.

Chapter 2

Research Approach [1]

[1]Parts of this chapter are published at: Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) Tool for Internet-of-Things business model exploration: A Design Science Research Approach In ECIS 2018, Portsmouth, UK., and Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) Designing digital tooling for business model exploration for the Internet-of-Things. In Desrist 2018, Chanai, India

2.1 Chapter Introduction

The Research approach is a generic plan that supports researchers to address, and answer specific research questions and therefore, to attain the research objective [192]. We adopt a Design Science Research (DSR) approach as the main research method. This method is suitable for our purposes because we aim to solve a practical problem (and create new knowledge) with the design and development of an artifact. This chapter focuses on the methodology we choose to address the research strategy, namely Design Science Research (DSR). The chapter concludes with a presentation of the DSR research parts and activities used for reaching the research objective.

2.2 Design Science Research (DSR)

2.2.1 Understanding DSR

Within the Information Systems (IS) field, two types of research have been undertaken: the *behavioral* and the *design (engineering)* research tradition. In the first type, scientists focus on either building and testing theories or acquiring a deep understanding of phenomena by making abstractions and generalizations. In this type, the research contributes to the descriptive and explanatory knowledge (X-knowledge) [121] [227]. X-Knowledge research enhances our understanding of the world and the effect of technology. For the second type of research, scientists build and evaluate artifacts (i.e., human-made objects), assumable useful for specific organizations. During the evaluation process, the researchers determine to which extent the developed artifact is useful and to contribute to the prescriptive knowledge (k-knowledge) ([227], [121]). k-Knowledge research contributes possibly with useful technological innovations for individuals, organizations, or society. The second type of research is known as Design Science Research (DSR) [153], see Figure 2.1).

DSR was first introduced in 1957 [50] as an attempt to systematically form designing. As a design-oriented research approach, DSR has its roots in the engineering field focusing on the '*sciences of the artificial*' [199]. DSR is defined as '*a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in un-*

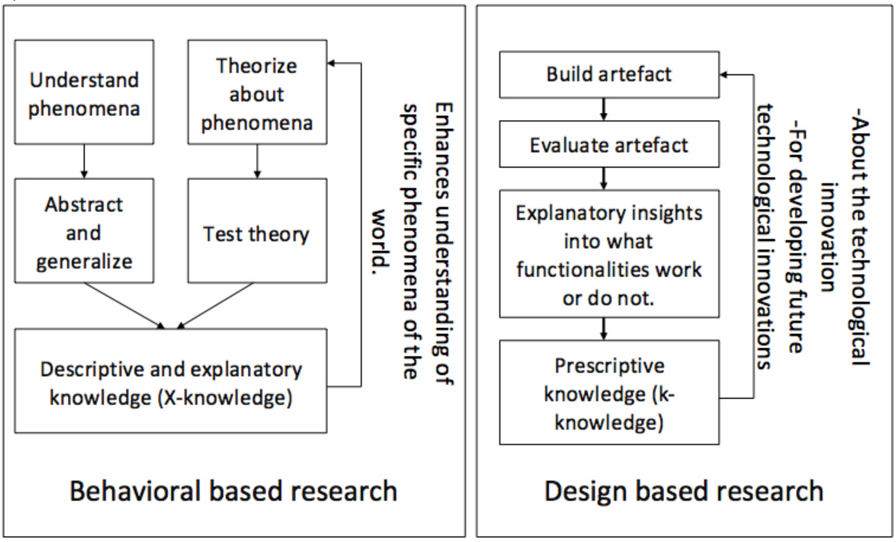

Figure 2.1
The two types of research (adapted from [227], and [121]).

derstanding that problem' ([120], p. 5). More recently, Goldkuhl and Sjostrom defined DSR '*as a practice loop, i.e., moving from problematic situations in a practice through design and back to an artifact-renewed and improved practice*' ([106], p. 69). Therefore, DSR is a suitable methodology for our study as we previously identified a practical problem that we aim to solve with a newly developed artifact that will create new knowledge. Additionally, we aim to provide an improved solution to the practice.

Hevner et al. discuss seven guidelines to be followed during DSR projects namely 1) design as an artifact, 2) problem relevance, 3) design evaluation, 4) research contributions, 5) research rigor, 6) design as a search process and 7) communication of research ([121], p.83). We follow these guidelines throughout our research and we discuss them in the next chapters of this thesis. Table 2.1 presents how the guidelines are followed for our research (and which chapter discusses each guideline).

2.2.2 Design in practice vs Design Science

The interest of the IS researchers for DSR is growing [106]. However the question is what makes design a scientific method and how it differences from design in practice. The major difference is that '*design for practice*' is focused on producing (useful) artifacts, DSR is focused, in addition to producing artifacts, on the discovery of new knowledge useful for the scientific community [215]. Additionally, with DSR, researchers can contribute to a general class of problems and organizational settings rather than on a specific design problem of a specific organization setting, like in the case of '*design for practice*' [219]. In essence, DSR integrates the '*design for practice*' with science that the systematic and structured attempts to produce new knowledge [162]. Our study aims to create new knowledge by designing, developing and evaluating a new class of artifacts that are domain specific and support business model exploration. Therefore, our study is a typical DSR project. With the new knowledge, we aim to add to the business model theory by evaluating and reflecting on artifact functionalities that influence business model exploration.

Table 2.1
Guidelines for DSR projects, explanations and relevant chapters of this thesis ([121]; [120], p.12).

Guidelines	Explanation	Chapters
Design as an artifact	Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.	Chapter 5: Detailed description of how we built the artifact.
Problem relevance	The objective of DSR is to develop artifact-based solutions for important and relevant problems.	Chapter 1: Practical problem and literature gap are discussed; Chapter 8: The relevance of the research is discussed.
Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via evaluation methods.	Chapter 7: We discuss the evaluation iterations and the results.

Continued on the next page

Table 2.1 – continued from the previous page

Guidelines	Explanations	Chapters
Research contributions	Effective DSR must provide clear and verifiable contributions in the areas of design the artifact, design the foundations, and/or the methodologies.	Chapter 8: We discuss the contributions to the theory and practice.
Research Rigor	DSR relies upon the application of rigorous methods in the construction and evaluation of the design artifact.	Chapter 2: We provide a detailed description of the generic research method (DSR), and the research activities undertaken throughout the research. Chapters 3-7: We discuss the specific research method(s) followed.
Design as a search process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	The research is structured in research parts where different research methods are used to solve specific problems that subsequently will solve the full problem.
Communication	Design science research must be presented effectively to both technology-oriented and management-oriented audiences	This thesis summarizes the methods, design, evaluation, results of this research.

2.2.3 IT artifacts and DSR

An artifact (or artefact) is defined as '*an object that is made by a person* [72]. However, a clear understanding of what an Information Technology (IT) artifact is is not available [175]. In simple terms, an IT artifact is the interconnection of various components [178] illustrated in a structured form [121], and aiming a specific goal. Some of the IT artifacts are methods, requirements, programming languages, or tools. Hevner et al argue that DSR artifacts can take the form of a [121]:

- conceptual object that is created as a way to describe or represent a specific type of phenomena. This type of DSR artifact has motivated research about IS that support organizations to have a competitive advantage within the industry (*Constructs*),
- conceptual object that describes and represents real phenomena by combining constructs and associations and their links (*Models*),
- a set of actions to achieve a specific outcome like a product or service outcome (*Methods*), or
- hardware or software system produced using a specific method to implement a construct or model to test how feasible it is to build this specific (hardware or software)system (*Instantiations*).

Regarding our study, we create a DSR artifact that takes the form of instantiations. More specifically, we design and develop an artifact (Instantiation) to test the feasibility of the functionalities it is based on, a software based on a specific and articulated method to test the feasibility of this software related to business model exploration.

When researchers build a DSR artifact, they aim to contribute to the theory and practice. The contributions can be specified by reflecting on to which extent the newly created artifact is useful (for a specific phenomenon), and by evaluating the design principles (or functionalities) identified for the design of the artifact [215]. The contribution of DSR projects can vary based on the scientific maturity [110]:

- limited scientific maturity when a DSR project provides a specific artifact as a solution for a specific problem,
- medium scientific maturity where a DSR project produces design principles and models, and

- high level of scientific maturity that leads to new design theories.

Our study aims to a medium scientific maturity as we aim to contribute to the business model exploration with a set of design principles (the functionalities of the artifact).

Regarding contribution to the practice, with the development of the design theories (i.e., the contributions to the theory), DSR researchers can provide a set of recommendations or guidelines to the practitioners, and/or by providing IT artifacts that are theoretically based and evaluated in practice [155].

2.2.4 DSR Genres

In the previous sections, we discussed the different DSR artifacts and the variant contributions. Iivari argues that there is a lot of confusion regarding DSR because of the different existing genres [126]. More specifically, he argues that two different DSR strategies can be found. In the first strategy the researcher designs and then evaluates an artifact as a general solution (usually based on academic interest) while in the second strategy, the researcher attempts to provide a solution to a requested problem (e.g., from a client) by first evaluating and then designing an a rtifact [125]. Goldkuhl and Sjostrom ([106], pp.67-68) elaborated more on the two genres and '*labeled*' the two genres. They labeled the first genre as *a laboratory approach*, in which DSR scholars address a general problem (conceived as a '*loboratory approach*') through the design of 'conceptual artifacts' and possibly materialized instantiations. The laboratory approach does not require specific and real problems in real-life practice contexts. They labeled the second genre as: '*a practice approach*' in which the DSR scholar solves real-life issues by building and implementing artifacts into practice. Collaboration with practitioners, in this genre of DSR, is essential ([106], pp.67-68). In essence, when a DSR research falls under the first category, the researchers create an artifact as a general solution for a class of problems without the need of a specific real-life content (laboratory approach), while for the second genre the researchers create a specific artifact for a specific context upon the request of a client [106].

The decision on what DSR genre approach will be followed depends on the research problem, and if the research is derived from gaps in the literature or a 'client' [106]. With our study, we aim to provide a solution for a set of problems, identified in the literature and not upon the request of a '*client*'. With our research we focus on a specific domain (to make our research more focused), and we aim to generalize our research to a larger set of domains. Thus, we follow the first genre of DSR to provide an IT artifact as a general solution for a class of problems.

This study focuses on developing an IT artifact as a solution for gaps identified in the literature. To do so a set of design requirements needs to be identified, tested and evaluated while we will be able to understand the context, the requirements, and the contributions. After the evaluation, we will be able to discuss the contributions in the theory and practice. As mentioned above, by using DSR we can obtain knowledge for a specific phenomenon. DSR '*is consistent with prior literature, it provides a nominal process model for doing DS research, and it provides a mental model for presenting and evaluating DS research in Information Systems (IS)*' ([184],p. 46). For instance, by using DSR as the research approach for our study, we can obtain knowledge from the build of the artifact and its use in a practical setting. Our study can be seen as a problem-solving paradigm positioned within the DSR [125]. For that reason, we argue that DSR is an appropriate research method for reaching the aim of our research. In the next sections, we discuss in detail the DSR approach we followed. Following the suggestion by Gregor and Hevner [111] we structure our DSR project in parts.

2.3 The DSR approach for this study

For this study, we use the DSR approach by Gregor and Hevner [111] a common approach used in IS. The activities are namely: Method, Background, Design Principles, Artifact description, Evaluation, Discussion, and Communication. During these activities, different research methods are used for data collection and analysis. DSR approaches do not explicitly mention what research methods should be used for each activity. It is suggested to break down the DSR process into four parts namely *problem analysis, artifact construction, artifact evaluation, and interpretation, theory construction and learning* [165]. Table 2.2 presents the research parts, the DSR steps, the research questions we aim to answer and the chapter that these steps take place.

Table 2.2
Our DSR activities and Research Methodologies (adapted [111]).

Research Parts	**Design Science Research steps (DSRx)**	**Chapter where this step is discussed**
1.Problem analysis	DSR1:Method; DSR2:Background	Chapter 2
2.Artifact Construction	DSR3:Design principles; DSR4:Artifact description	Chapters 3-4
3.Artifact Evaluation	DSR5:Evaluation	Chapter 7
4.Interpretation, Theory construction and learning	DSR6:Discussion; DSR7:Communication	Chapters 1-8

2.3.1 Research part 1: Problem Analysis

In this part, we are reviewing the DSR methodology and background. During the research part one, we aim to give answers to the first research question *'What can we learn from exploring the existing business model tooling?'* (RQ1) and the instrumental question *'what is a suitable domain to develop such tooling for, and most likely to need business models exploration?'*. First, we structure the problem by identifying the literature gaps and describing a potential solution. Based on the potential solution we review the literature. We begin by reviewing the core theories we identified from the research questions. More specific we review the literature of business models and business model innovation process (design, experimentation, implementation). With the literature review of the theories, we aim to understand the concept of the business models, BMI, existing business models tooling, what is the main focus and what is missing. To understand the problem we focused on a specific industry, the automotive ecosystem, as we identified it as an industry with major IoT disruptions. Figure 2.2 illustrates the activities of research part one.

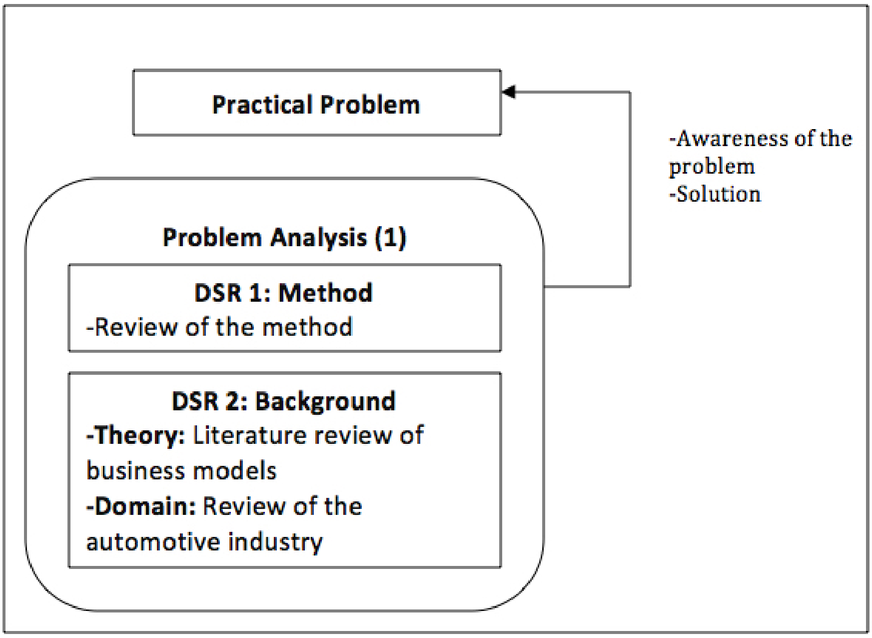

Figure 2.2
The two types of research (Activities during research part one: Problem formulation).

2.3.2 Research part 2: Artifact Construction

For the research part 2, we aim to answer the second *'What activities are undertaken during business model exploration?'* (RQ2) the third *'What are the main design requirements for designing tooling that supports the business model exploration activities?'* (RQ3) and the fourth research question *'What functionalities can support business model exploration?'* (RQ4). In this research part, we aim to create a set of design requirements for the design of a solution to the problem in the form of an artifact. These requirements will support the development of the functionalities of the artifact that we will test and evaluate.

Regarding the latter sub-question, in this research part, we focus on the development of the artifact. The development of the artifact is based on the formulation of a solution, the design requirements and a set of additional activities. During research part 2, different research activities will take place. More specifically, we will investigate the literature by doing a textual analysis (based on the design requirements we identify) on the elements needed on the artifact that will allow us to develop the artifact. Secondary analysis of interviews will inform the non-functional, contextual requirements, and assumptions for the development of the artifact. A working prototype will be created that will include the complete design with all the requirements and assumptions. Feedback will be collected regarding technical, contextual and other specifications before the final evaluation. Figure 2.3 illustrates the activities undertaken during the research part 2.

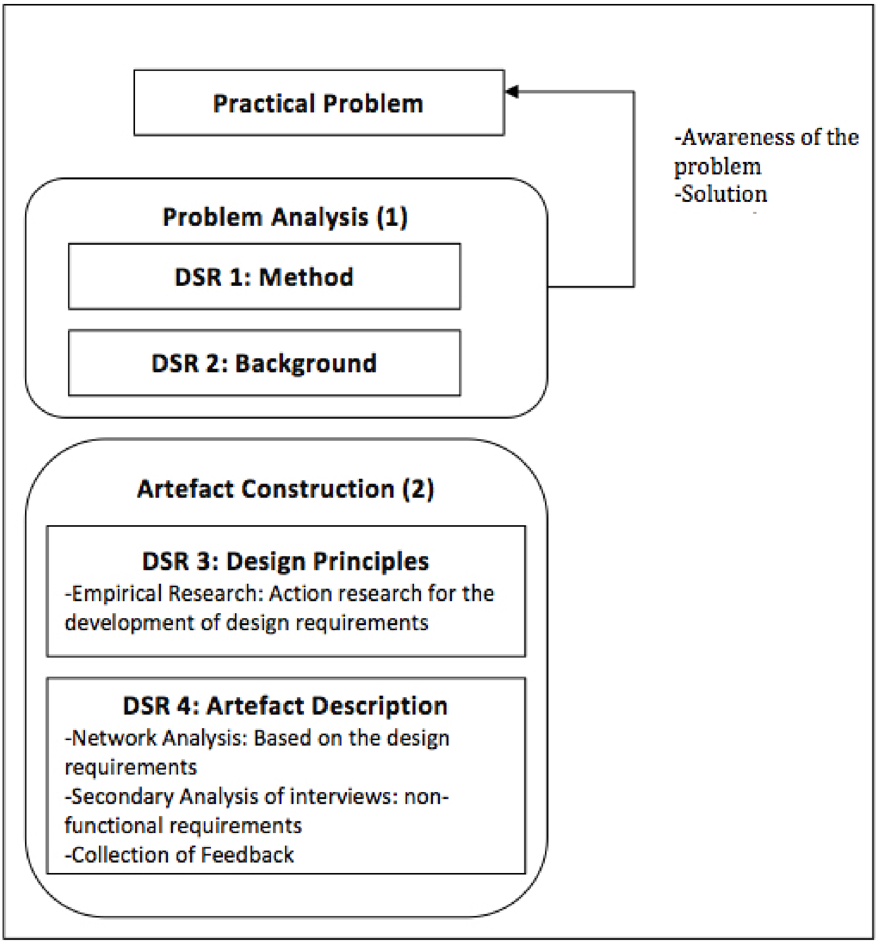

Figure 2.3
Activities during research cycle 2: Artifact Construction.

2.3.3 Research part 3: Artifact Evaluation

The third part of our research involves the evaluation of the developed artifact. This part contributes to the final sub-question *'What are the effects of the developed tooling on the business model exploration process as identified in theory and practice?'* (RQ5) Evaluation is considered an important and central step for a DSR study [96] and it should deliver evidence that the evaluating artifact is a satisfactory or un-satisfactory solution to the identified problem [165]. DSR is an iterative process and therefore, we will do a two-step evaluation in between the evaluations we make improvements both on the artifact and the experimental design.

The first evaluation will include testing of the artifact's non-functional requirements, feedback from different informants regarding improvements on the artifact functionalities, and finally the first conclusions regarding the effect of the artifact on the business model exploration. The data collection of the first cycle evaluation will include interviews, short questionnaires and an experimental setting with the use of pre- and post-questionnaires. The first cycle iteration includes the alpha and beta testing as well as an initial pilot where participants test the artifact.

During the second evaluation, experiments will be conducted to evaluate the effect of the artifact on the business model exploration. We will conduct pre- and post-test questionnaires on the extent to which users are able to achieve the goals specified in the design guidelines. We will use the same questionnaire items while testing an alternative tool with similar functions as a control condition. In chapter 6 we analytically describe the whole evaluation process. Figure 2.4 illustrates the evaluation activities of research part 3.

2.3.4 Research part 4: Interpretation, Theory construction and learning (4)

In the fourth research part we aim to provide an answer to the last sub-question: *'What are the effects of the developed artifact on the Business Model exploration process?'* To do so we will analyze the data and interpret them. By interpreting the results we will make conclusions regarding the effectiveness of the developed artifact to the business model exploration. The analysis of the data will be held with the use of the SPSS statistical program. Additionally, interpretation of the results will be supported with the analysis of qualitative data collected during the

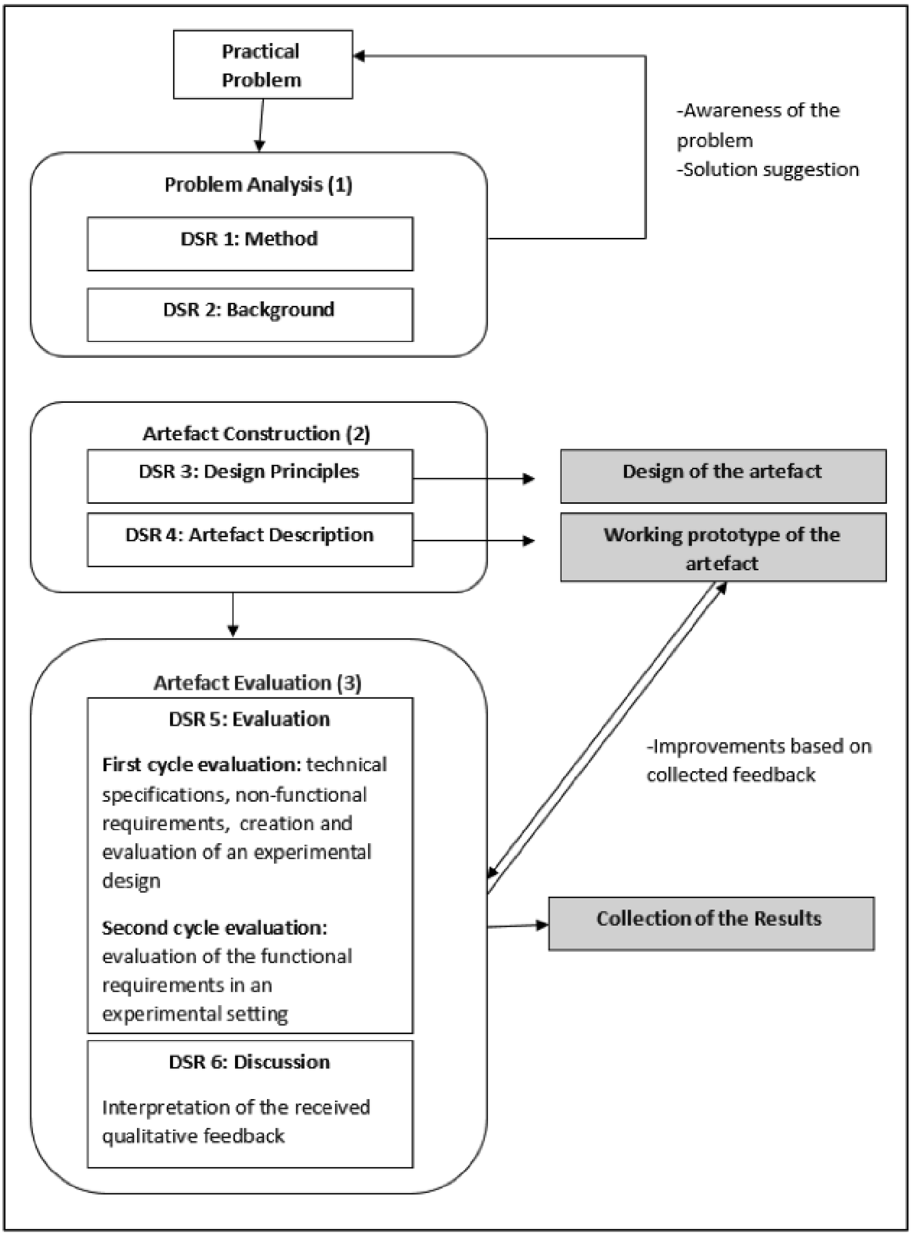

Figure 2.4

Activities during research cycle 3: Artifact Evaluation.

evaluation process. The results will be presented in chapter 6.

The final activity of this part and of the whole DSR process is the communication of the results and how they contribute to the scientific knowledge [121]. Additionally, during that activity, we will reflect on the theory and how our study enriches the existing theories, and what we learn during the whole process. The publication of the results is important as it will reach an audience with relevant scientific knowledge and allow them to use the results to future studies, or to apply the developed methodology to different studies. Publishing and communicating is the tool to expand the existing knowledge. This thesis aims to communicate in detail the whole DSR study. In chapter 7 we elaborate on the contributions, lessons learned and future improvements and recommendations for future studies. Figure 2.5 presents the fourth research part in detail.

2.4 Chapter Conclusions

We follow a DSR approach to develop an IT artifact (i.e., business model exploration tooling) as a solution to a specific problem (i.e., business model exploration in the digitalization era). The building and evaluation of the artifact take place in four research parts. During these four parts, we perform seven activities (following recommendations of DSR academics).

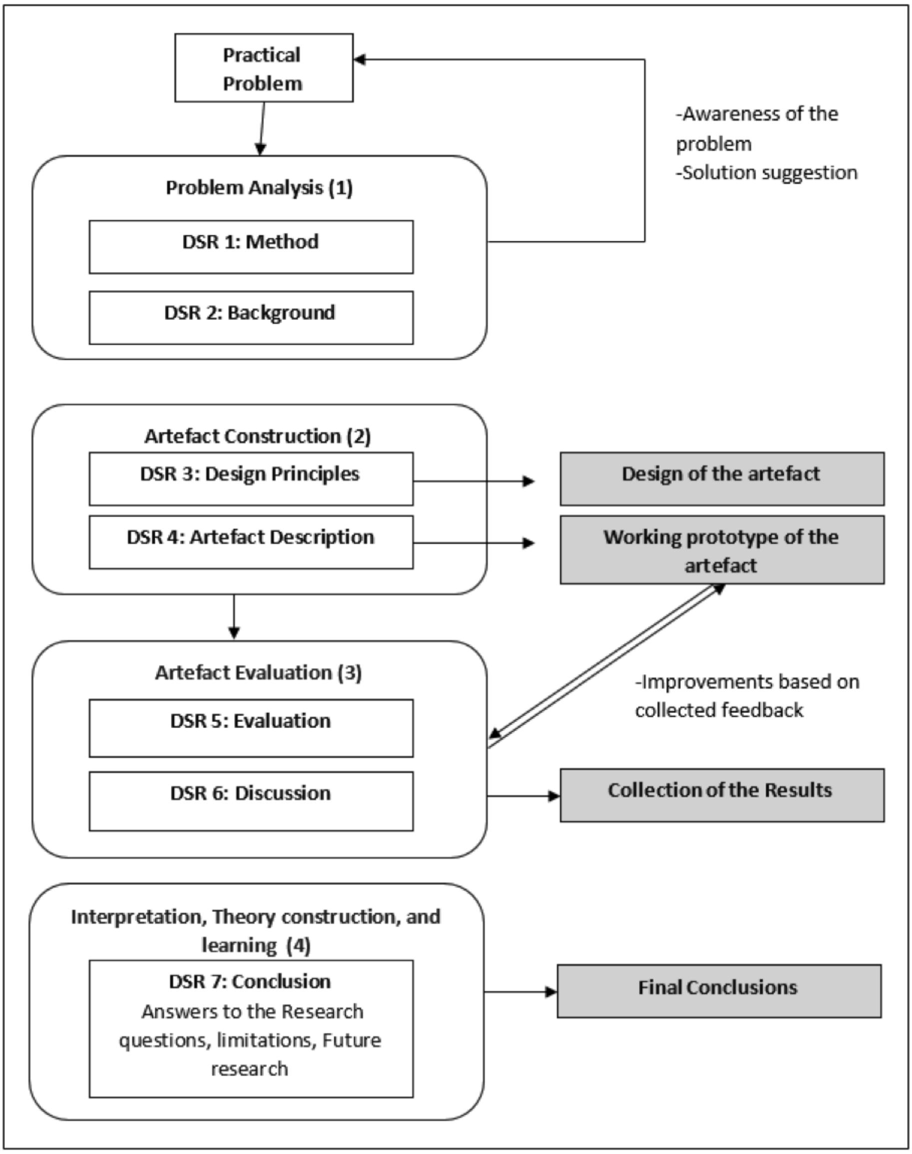

Figure 2.5

Activities during research cycle four: Interpretation, theory construction and learning.

CHAPTER 3

THEORY [1]

[1] This chapter is based on: Bouwman, H., Athanasopoulou, A., and De Reuver, M. (2016). The disruptive impact of digitalization on the automotive ecosystem: a research agenda on business models, platforms and consumer issues. Proceedings of the 29th Bled eConference, Bled, Slovenia.

3.1 Chapter Introduction

The present research aims to build a digital artifact to support business model exploration. This chapter contributes to the research part 1: *Problem and Solution formulation.* In essence, in this chapter we discuss and present the theories that we needed for our study, having identified the literature gaps (see chapter 1). We also formalize the problem in detail and identify the theoretical basis of a potential solution. Therefore, in this chapter we address the first research sub-question: *'What can we learn from exploring the existing business model tooling?'* (RQ1). To answer this question we adopted a literature review approach as the main methodology. We started the literature review by understanding and defining the concept of business models. Here, we present the different definitions and show how we decided which one we would use for our research. We discuss the concept of business model patterns, how they are used, and how they can support our research.

We start the literature review by understanding and defining the concept of the business models. We present the different definitions and we conclude with the one we will use for our research.

Next, we discuss the concept of business model innovation and the drivers that require this innovation. We introduce the different phases of business model innovation, with a particular focus on the business model exploration phase. We use two illustrative cases as examples of how business model exploration takes place in practice, and we reflect on why we focused on business model exploration for our study (for these examples, we followed a case study/interview protocol). We then, focus on the tools created for the different phases of business models.

In addition, we discuss the concept of BMI tooling. First, we discuss the literature on BMI tooling, present the different types of tools, and provide examples to illustrate them. We conclude the chapter with reflections, answers to RQ1, and the decisions we made for the rest of the research.

3.2 Chapter methodology

A literature review is essential for any research within academia [143] because it provides an overview of what is already known [28], allowing the identification of the literature gaps and the contributions of the research approach. The purpose of the literature research phase is to understand the core concepts and theories, and subsequently to position the specific research. In this phase, the '*justificatory knowledge*' [110] is studied. '*Justificatory knowledge*' is the existing theories that we need to make design decisions to create an artifact. These theories are called kernel theories and they provide a theoretical grounding for the designed artifact [105]. To find previous studies, we searched for studies in the online databases ScienceDirect, Google Scholar, and Scopus. Through these databases, the following sources were identified: peer-reviewed scientific journals, conference proceedings, special issues, books, industry publications, and web blogs. The use of keywords for search purposes was important. For this chapter various keywords were used such as: 'business models', 'business models innovation', 'innovation', 'business models and ICT', 'IS and business model', 'ICT and business model innovation', 'BMI and ICT', 'operational model', 'business model tooling', 'tools for business model', 'tooling for BMI', 'BMI tooling', 'online BMI tooling', 'offline BMI tooling', and 'business model exploration'.

We performed an initial analysis of these articles reading the abstracts, introductions, and conclusions. When a relevant paper was found, further reading was done. In some cases, the title of a paper seemed relevant but the main body did not provide enough information for our review. These papers were therefore excluded from the review. Accordingly, the snowball approach was used. When a paper was identified as relevant, the next step was to search its bibliography for other useful studies. When the title of a citation was relevant, we read the abstract, introduction, and conclusion sections. We focused more on a paper if it contained more useful information. In parallel, we searched in the online databases for newer articles citing the paper that we were examining. Forward snowballing allowed us to identify more recent papers and to ensure that the identified gaps had not already been filled. In the following sections, we present the results of our literature review and reflect upon the results related to our study.

3.3 Business models

Many scholars and practitioners agree that enterprises should focus on innovating their entire business model. Business models connect technical potential with economic value [59]. The objective of this section is to offer an overview of theories regarding business models. The theoretical grounding will provide us with a basis to understand what a business model is.

The development of ICTs and the exponential growth of the internet led at the start of the new century to business models attracting the attention of both practitioners and academics, and the term started to become relevant to various scientific fields, such as strategic management (e.g., [17], [145]) (2) technology and innovation management (e.g., [138], [179], [56]), and (3) Information Systems (IS) (e.g., [22], [39], [186] [191]). However, the concept of business model is still not clearly defined among academics [99]. As a result, the term is often used with different meanings within industry and academia ([179], [59] [66], [233]), see Table 3.1 for an overview.

Table 3.1
Chronological overview of business model definitions related to the content of business model components

Description of business models	**Source**
The core logic; value creation	Linder and Cantrell [145]
A complex set of independent routines; discover; adjust; fine-tuned	Winter and Szulanski[232]
A design; value creation; business opportunities	Amit and Zott [17]
(The heuristic) logic; economic value	Chesbrough and Rosenbloom [58]
A story, how enterprises work; customers; value source of profitability	Magretta [150]
An enterprise's strategy aspects	Leem, Suh, and Kim [141]
A concise representation; set of decision variables	Morris et al. [172]
A blueprint; service definition; intended value for the target groups; source of revenue; service delivery; required resources; organizational arrangements; financial arrangements	Bouwman et al. [39]

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Table 3.1 – continued from the previous page

Description of business models	Source
A model; reflection of enterprise's strategy	Casadesus-Masanell and Ricart [51]
The rationale; value creation; value delivery; value caption	Osterwalder and Pigneur [179]
A model/a recipe: business's activities; elements combined to make them work to enable users to figure out how their world works in the practical context, as well as in academia. They can be found as exemplar role models that might be copied, or presented as nutshell descriptions	Baden-Fuller and Morgan [20]
An enterprise's strategy aspects; operation, consequences	Casadesus-Masanell and Ricart [51]
An enterprise's strategy aspects	Solaimani and Bouwman [201]
A combination of activities; generate value for enterprise; and its customers	DaSilva and Trkman [66]
A representation of the relevant activities; how products/services are generated; company's value-added component	Wirtz et al. [233]
Attributes of real firms	Massa, Tucci and Afuah [158]

As a term, 'business model' was introduced over 60 years ago by Bellman [29], although the concept was hardly investigated in the subsequent decades. At the beginning of the 21st century, academics defined business model as the way an enterprise does business ([102], [160]), or as the core logic for how the enterprise creates value ([131], [145]). Osterwalder and Pigneur [179] added the concepts of 'value capture' and 'value delivery'. Amit and Zott argued that business model is a design representing the elements that are needed in order to create value for new business opportunities [17]. More recently, scholars describe business models as the combination of activities that describe how services (or products) can generate value for the enterprise and its customers ([66], [233]). Other scholars see business models not as a separate entity but as the reflection of the enterprise's strategy aspects ([51], [141]) or as a guide for the creation of a business model. While scholars define business models differently, similar views can be found within the literature. In management studies, there are two views on business models: The first sees business models as *activity systems* and the second sees business models as a *cognitive tool*. Scholars supporting the first approach regard business models as something real, and outside people's cognition [156], and as a '*set of independent organizational activities centered on a focal firm, encompassing activities that are either conducted by the focal firm, partners, customers or vendors.*' [239], p. 3). Thus, literature following this view addresses the logic of '*how*' a company delivers value (products or services) to the customers and the cost (idem). Scholars who hold this view see business models as purposefully designed systems or as emerging systems (i.e., factors that foster successful business models over time) [213]. Scholars holding the second view ([19], [158]), regard business models as '*cognitively constructed representations*' ([213], p.8), of decision makers' cognitive models [19]. This stream of literature aims to explicate the logic and process of schemas that can ideate and design business models ([156], p. 100).

For our research, we considered business models as a cognitive tool that explains the business logic. We adopted the definition by Osterwalder, Pigneur and Tucci who define business model as '*a conceptual tool set of objects, concepts and their relationships with the objective to express [...] what value is provided to customers, how this is done and with which financial consequences*' ([179], p. 3). This definition was the basis for the further steps of our research and the design of the artifact.

3.4 Business Model Innovation (BMI)

3.4.1 Understanding Business Model Innovation (BMI)

Since the early 21st century, studies on Business Model Innovation (BMI) have emerged that led BMI to become a research field separate from that of business models [92]. As with the term 'business model', scholars define BMI in different ways due to inconsistencies in the BMI term conceptualization. Scholars perceive BMI as an innovation that goes beyond innovating the offering, to involve innovation at a system level [146]. BMI can include new offerings, new processes, new types of innovation, and new revenue revenues models, but it also requires a new logic of how value is created and captured [84]. To do BMI, enterprises need to answer questions regarding their offerings, the needed decisions, the actors responsible for these decisions, and why they should do these activities [103]. The diversities on what is considered BMI can be tracked in the variant BMI definitions in the literature. Table 3.2 presents some definitions in a chronological order.

Table 3.2
Some definitions on the BMI (listed chronically and as presented by the authors mentioned).

Description of the BMI	**Source**
'When a company makes business model replacement that provides product or service offerings to customers and end users that were not previously available [...]'	Mitchell et al. [169], p.17)
'...the discovery of a fundamentally different business model in an existing business.'	Markides et al. [154]
'...the paths that can take upon the change'	Chesbrough et al.[57]
'...[the] changes [in the business model] with short- or long-term impact'	Habtay et al. [114]
'...[the] modification or introduction of a new set of key components – internally focused or externally engaging – that enable the firm to create an appropriate value.'	Hartmann [149]

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Table 3.2 – continued from the previous page

Descriptions of the BMI	**Source (listed chronically)**
'... a new integrated logic of value creation and value capture, which can comprise a new combination of new and old products or services, market position, processes and other types of changes.'	Bjorkdahl and Holmen[35]
'... [the] design and implementation of an activity system that is either new to the market/ industry /world or new to the focal firm, new in terms of content, structure and or governance, for established firms; radical or incremental The more radical the BMI, the more wide-ranging the system-level changes.'	Zott [237]
...[the questions] enterprises need to answer regarding their offerings, the needed decisions, the responsible actors for these decisions, and why to do these actions.'	Girota and Netessine [103]
'...changes in business logic, that are new to the focal firm, yet not necessarily new to the world, and have to result in observable changes in the practices of a business model'	Pucihar et al [81]
'[...]the innovation in company's BM that is new to the firm and results in observable changes in the firm's practices towards its customers and partners.'	Heillilä et al. [117]

Continued on the next page

Table 3.2 – continued from the previous page	
Descriptions of the BMI	**Source (listed chronically)**
'[...] the designed, novel, non-trivial changes to the key elements of a firm's business model and/or the architecture elements'	Foss et al. [92], p. 2001)
'[...]systematic changes in the business logic of companies when creating and capturing value for both customers and companies'	(Bouwman et al.[42], p.149)

For this study, BMI is considered as '*the innovation in company's business model that is new to the firm and results in observable changes in the firm's practices towards its customers and partners* [117].

The literature discusses BMI in two ways: as a *process*, and as an *outcome* ([92]. Literature describing BMI as a process focuses on capabilities, leadership, and learning mechanisms towards a successful business model. These studies describe the context of novel business models and concluding from a specific industry, market, or firm that has already experienced disruption [84]. Other studies describe BMI as the outcome of an organizational change [92]. These studies describe the context of novel business models, and drawing conclusions from a specific industry, market or firm that already experienced disruption [84]. The first steam of literature is interested in the BMI dynamics, while the second approach is interested in investigating BMI ex post [92]. Our study investigated BMI as a process, where innovations enable changes in business models. We aimed to explore how the BMI process unfolds when innovations enable changes. Innovations can be either incremental or radical. Incremental innovations are small changes in only one element of a business model [149] improving existing business models [65]. Radical innovations are drastic changes in the way an enterprise works and the way it delivers and captures value ([53], [154], [169]). These innovations enable changes related to different phases of the BMI, such as design growth or exploration. There are different BMI phases such as the explore, the design, the test and the grow phase [67]. While the phases can also be interconnected, in our research we focused on the exploration where opportunities (e.g., disruptive technologies) drive organizations to discover new business models.

In innovation in general, the exploration of processes is related to new possibilities, and exploitation is related to old certainties. More specifically, '*exploration includes [...] search, variation, risk taking, experimentation, play, flexibility, discovery, innovation*' while '*[...] exploitation includes [...] refinement, choice, production, selection, implementation, and execution*' ([152], p. 71). Similarly, BMI can be divided into two stages, namely business model exploration and business model exploitation [205]. The need for business model exploration, and therefore BMI, occurs with the development and use of technologies, or emergence of new ways of using existing technologies or a shift from a product to a service-oriented logic [39]. In the following section, we discuss how opportunities drive the need for business model exploration and therefore BMI.

3.4.2 Opportunities as enablers for BMI

In the literature little is discussed regarding the enablers of BMI. The main focus of scholars is on internal drivers such as innovativeness (e.g., [124]), leadership (e.g., [57]), culture)e.g., [203]), business performance (e.g., [203], [209]), while the external opportunities that enable innovation (e.g., market change, customer preferences, technology change) (e.g., [67]) are not extensively discussed. Opportunities were of interest for our research, as they require rethinking the business models for value creation and capture. Next we discuss the opportunity creation theory.

The idea that opportunities can bring economic growth to organizations has been discussed for many years [16]. Opportunities are meaningful when they are part of the social reality of entrepreneurs (idem). Venkataraman [220] argues that opportunity only exists within markets when there is competitive imperfection exists. Examples of competitive imperfections are entry barriers, heterogeneously distributed capabilities, or the opportunity to produce heterogeneous products [16]. Alvarez et al. argue that there are two types of opportunities: that are *discovered and exploited*, and that are *created and exploited* (idem).

Opportunity *creation* is more uncertain for various reasons. The possible outcomes are not known as [18]. Additionally, an initial idea for creating an opportunity can be either intentional or blind in nature [176].

However, often the entrepreneurs cannot see the end of the process because opportunities cannot be fully observed or understood before they have market reaction. Furthermore, there might be a mismatch between an entrepreneur's idea and objective reality and that might lead to reassessment of the idea after the launch of the product in the market [176]. Or, there might be a mismatch between the initial idea and the social constructions of the customers. During the process the opportunity evolves toward the needs in the market and the initial assumptions might change too [176]. Finaly, there is no fixed goal opportunity development, the opportunities emerge during the development process' [176]. However, as Ardichvili, Cardozo and Ray point out '*the elements of opportunities are recognized, but the actual opportunities are made, not found*' ([18] p. 106). Opportunity requires some competencies such as adaptive and flexible decision making capacity, remaining flexible throughout the process, entrepreneurial experience and diverse knowledge [80]. However, not all opportunities are viable [202]. After opportunities are noticed, the next step is to figure out whether and, if so, how these opportunities can affect the business model (e.g., what technologies to use, which market to focus on), and how they can be addressed through new offerings, processes, or services [209]. Opportunities can be seen as enablers of BMI, as during the process of opportunity creation, the concept of business model needs rethinking to be able to support the opportunity creation, and to create and capture value from it.

3.4.3 Technology as a BMI enabler

An example of such an opportunity is disruptive technologies. Bower and Christensen characterize a new technology as disruptive when it lacks refinement, has performance problems, disrupts an existing market or creates a new one, and eventually leads to new products [43]. Most of the drivers can both offer opportunities and pose threats to an enterprise's business model. Regarding opportunities, technologies can create the need for enterprises to innovate their business model [129], to change or update the ways to create and capture value [181] and as a result to increase their profits and become more competitive [23]. Due to the changing technologies, enterprises might need to adjust their business model [145] Scholars argue that, in times of change, where both opportunities and threats arise in the internal or/and external environment, it is valuable for enterprises to rethink their business model if they want to stay competitive and profitable [48]. Enterprises might need to rethink their position within the market, target a new target group or to change their suppliers [200], and do BMI. For this study, we focused only on BMI driven by disruptive technologies.

Disruptive technology innovations in the environment of a company are often considered to affect business models. For instance, in the seminal work by [59], it is assumed that business models explicate the value that technology can create. Others have argued that business models mediate the link between technology and performance [19]. Technological developments (e.g., the Internet) have increased the interest of the academics and practitioners in business models. De Reuver et al. [68] argue that organizations need to reconsider their business model to stay up to date with factors such as socio-economic trends, technological developments, and political and legal changes. While these factors can be recognized as drivers of new business models, the literature sees them as enablers driven by customer value [86].

Most conceptualizations of business models do not explicitly link technology innovation to business models. For instance, within the most widely used ontology of the Business Model Canvas, the components of channels and resources may or may not contain technologies [179]. In alternative ontologies, such as VISOR [79], or STOF [39], technologies are an integral part of the business model. According to their models, enablers such as technological innovations affect business models by enabling new services and products. Such technology-enabled service and product innovations offer new ways of value creation, which subsequently leads to new ways of value delivery and capture. The role of a business model for new technologies is twofold: in one hand new technology is needed to redesign business models, and on the other hand, innovative offerings might require new technologies [61]. Hence, we posit that service and product innovations mediate the impact of technological innovations in the business model as a whole.

3.5 Business model exploration

One potential solution for enterprises with radical changes during opportunity creation is to do business model exploration, which allows enterprises to discover new business model opportunities [67]. For our study, we were interested in opportunity creation based on the assumption that during the process of opportunity creation business model design might be more challenging, as many components of the business model might be unknown. Additionally, we argue that toward the creation of this competitive advantage, the exploration of business models will be needed, until the organization achieves a revised business model.

3.5.1 Business model exploration conceptualization

Available publications present the process toward a business model as a linear process, while in reality, practitioners face the uncertainty of the evolving markets [30], and therefore the process requires an iterative approach (e.g., going back and forth between business model design product development) toward a new business model. Mason and Spring [157] argue that a linear sequence of activities in which business models are first designed and then implemented is unlikely. Rather, business models and their developmental practices are seen to interact in an iterative and evolutionary manner.

Definitions of 'business model exploration' are limited as the concepts have been given different names (e.g., change, trial-error). Later Osterwalder et al. [179] mentioned that enterprises need to adopt new business models or change existing ones while Chesbrough [57] points out that in times of change enterprises need to design an alternative business model.

Only recently, scholars started to study empirically how business models are being developed [91]. Sosna et al. [203] describes the business model exploration as the iterative process where business models are tested until a revised and assumedly successful business model is achieved [202]. Al-Debei and Avison [11] add that business models need to be continually reviewed to fit the uncertain, complex environments, while Teece [209] added that during this iterative process strategic choices need to be made. As common elements of business model exploration, we consider the following processes: (1) develop initial ideas on the new business model (*ideate*) [53], (2) conceptualize alternative business models (*reframe*) [203], (3) explore and assess alternatives (*envision*) [117], and (4) formulate concrete actions to implement the business models (*action-formulation*) ([20], [161], see Figure 3.1.

Based on the above we define business model exploration as:

The iterative process through which new business model ideas are created, conceptualized and tested until a revised, alternated, and assumedly

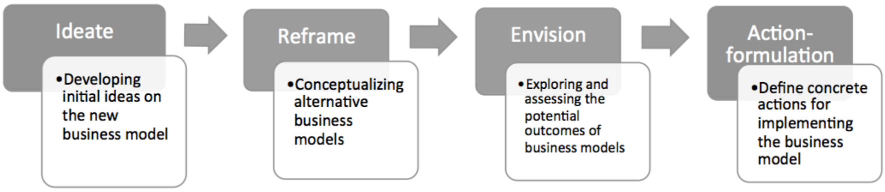

Figure 3.1
Business model exploration process.

viable business model is achieved.

3.5.2 Examples of business model exploration

Here, we present two real-life examples of how enterprises undertake business model exploration. While these two cases have some similarities (e.g., same EU region, family-oriented businesses, limited business model experience), they also have some differences (e.g., different sizes, different industries). For these two cases, we collected information through semi-structured interviews with the owners (face to face and online via Skype). The interviews were recorded and transcribed. To conduct and reflect on these two cases and understand business model exploration, we used a case study/interview protocol that included questions on the nature, drivers, and outcomes of BMI and the process of BMI. Extensive case descriptions were then developed in order to analyze the business model exploration. The cases have been anonymized, based on the preferences of the interviewees/business owners. Thus, we do not mention the names of the businesses or the interviewees.

3.5.3 The case of a micro-sized pastry shop (Example 1)

Our first example is a micro-sized pastry shop founded over 30 years ago located in a port city with 200.000 inhabitants. The micro-sized company offers its handmade products to the local market. The company is customer centric. Their main concern is to satisfy their customers by providing handmade products of high quality. They said that they prefer to make less profit than to offer products of lower quality. The company was started by the mother and passed down to her daughters (the current owners). Initially there was only one shop. After the daughters took over they opened two more (the first shop is now the company's lab). For special occasions, they are responsible for catering. Its original business model was fully product-based business logic. Due to external factors (i.e., financial crisis), the owners had to revise their business model. However, the interviewee said that they were not aware of the concept and that they do not use a specific business model ontology or methodology for their BMI, nor do they use specific tooling for their business model. The interviewee mentioned that they experiment with changes and they introduced new products or services based on their own intuitiveness, and the customers' requests (for instance customers asked for breakfast offers and the enterprise did it). During the last eight years (after the ownership has been transferred to the current owners, and the financial crisis occurred), they had implemented a series of changes took place such as offering their products in small quantities to eat in or take away, and in larger quantities for special events such as weddings and baptisms. They also made some changes to the products. They constantly update their product line based on the market and customers' requirements. For instance, they introduced "healthier" products. In addition, they collaborate with other businesses (e.g., a knitting equipment store) that offer classes for free. The participants only pay for their coffee or pastries. Another change they made was to open another shop. They decided that that would bring them more customers and make their business more visible to the local market. On the other hand, they have not changed their market. They try to keep their customers and whenever they find an opportunity they offer their services and products to other markets. No technology adoption apart from light use of social media. Measurements of the performance based on customer satisfaction and royalty were made. A change is considered successful if they do not lose money.

3.5.4 The case of a medium sized manufacturing business (Example 2)

Our second example is a medium-sized construction and manufacturing business specialized in products made of wood. They are located in the same region as the pastry shop, but in a different city and they were affected by the same external factors (i.e., financial crisis). The company was founded more than a decade ago. They are specialized in the design and construction of large and complex timber structures as well as the processing and trade of timber. Their manpower (15 people) consists of architects, engineers, designers, financial advisors, on-site supervisors, and craftsmen, who provide excellent customer service before and after a project. To them, they provide scientific knowledge, years of experience, and the excellent quality of their materials. They focus on the quality of their equipment as they adjust their mechanical equipment to meet the most advanced European specifications. Their main customers are hotels (big luxurious timber constructions; small timber constructions from the production line), builders, contractors, and craftsmen (raw materials), the public sector (mainly archaeological/excavation sites), and individual house owners (small timber constructions; for their houses upon request or from the production line; architectural drawings). They offer products and services upon customer request and have their own production line. The company is customer centric. Their aim is customer satisfaction, by having knowledgeable and experienced personnel and offering the best quality. They prefer to make less profit than offer products of lower quality. The company needs resources—wood, steel, and copper—to operate. Their main suppliers are located in the same region as them. They import special raw materials from abroad. In general, they have partnered with the same suppliers for years. They cooperate with other businesses to support them in some activities. Two examples are the use of external accountants (when needed) and external cleaning services. They own their transportation vehicles.

Their original business model was based on supply and demand. Due to external factors (i.e., financial crisis), they are revising their business model and exploring new paths. As noted by the interviewee the company makes plans for the future: '*[the president] is always looking to the future and says what he want to change or innovate in the company but we are not doing it in a really organized manner as other larger companies are. We say that we want to do something and we start doing it. So we start and if we see that is going nowhere we change 'paths'*. As the interviewee said, they explore and change paths when needed; however, he also said that the external factors had made them take fewer risks. The company adopts new ideas and has brought new materials to the regional market. The company adopts new ideas. They brought new materials to their regional market. Their BMIs are novelty focused. The company aims to create new products for the customers (production line). The production line will be focused on lightweight, affordable wooden products (e.g., benches). The company also aims to enter a new market abroad.

While they are business focused and more aware of business models compared to case 1, they do not use a specific business model ontology or methodology for their BMI. Nor do they use specific tooling for their business modeling. Strategic decisions regarding the business are made after discussions with the board of directors. In the production departments, employees know what they have to do. If they need to switch positions or help other departments, the president discusses it with them. External stakeholders are not involved in the managing of the processes. The main plans are to expand the business, that is, to expand the range of products and services offered (in order to increase their customers) and to get new customers by entering a new market abroad.

Additionally, they have lowered their prices. Essentially, they now offer luxurious products at more affordable prices. It should be noted that their prices are still higher than their competitors' because they want to offer the best quality possible. The main change in their business model is that they need to go abroad and find new clients that can afford their products. No changes have been made regarding technology. They have not invested in new technologies lately because they are pricy and not that useful, although the equipment they have is the most recent possible, compared with their competitors. They have made no major changes to their organization. It remains flexible, based on customers' requests and other external factors. They measure their performance through the outcomes (i.e., when a change leads to increased profits). They count on their customers' satisfaction and loyalty. The noticeable changes are related to the products they want to offer, and not the operations. They want to make smaller products on their production line. They have the equipment they need to do so. In other cases, they work on designing and making their standard products or doing other activities. The company's strategy continuously changes along with the demands of the market, business opportunities, and the economic situation. After opportunities are identified, the business changes its processes and operations. If needed, management relocates employees to different departments.

3.5.5 Discussion on the two cases

In the above two examples, the business owners, while not totally aware of the business model concept, undertake business model exploration. They have made changes to elements of their traditional business models, evaluated what was a good move and what was not, and adopted some of these changes. In the first example, the changes were based on intuition, while in the second example the entrepreneurs made changes more conservatively and after evaluating the potential outcomes. These two examples show that in times of change enterprises need to innovate their business models. In both cases, the enterprises did not have a clear design of the business model, but they decided to experiment with new offerings, target groups, revenue models, collaborators, etc. In both cases, the business model changes were applied and evaluated based on various indicators and were then considered successful or unsuccessful. During the business model exploration period, the pastry business owners (who were less knowledgeable about the business model concept) took risks, while the timber product business owners took fewer risks and only proceeded with a change after they had estimated the results of that change. In both cases, the entrepreneurs did not have a design of their existing business model nor a plan for the future business model(s), and they did not use any tools to support them throughout the process.

In these two cases, we see that enablers made the enterprises rethink their business models (though in the first case, not consciously). We see that suggested changes to the business models emerged due to opportunities. We also see that the businesses created a list of suggested changes and conceptualized them in the business models as described in our conceptualization of business model exploration. Additionally, we see that in the two cases, alternative business models were created, such us for new offerings or markets and that these were tested and implemented in practice. After testing some of the alternative business models, the enterprises decided which changes were actually worth implementing, as we discussed when conceptualizing of the business model exploration. Finally, we see that the whole process led to new business ideas, some of which are very different from the initial offerings. The two examples are in line with our conceptualization of business model exploration. They are real-life examples of how opportunities enable alternative business models through idea generation, creation, testing, and decision making.

3.6 Business Model Ontologies

We previously, presented the heterogeneous opinions and definitions of the 'business model' term. Early scholars identified the components of a business model as value of the enterprise (e.g., [15], its value structure ([99]), the strategy [15], the core capabilities (e.g., [179], the external relations (e.g., [12]), the revenue model (e.g., [133]), the financial model (e.g., [179]), process (e.g., [15]), and marketing model [69].

Gordijn, Osterwalder, and Pigneur [109] argue that business models can be further explained with ontologies. Osterwalder and Pigneur describe business model ontology as *'a set of elements and their relationships that aim at describing the money earning logic of a firm'*([179], p. 47). The common element of the business model ontologies is to explain what a business model is and to serve as a communication tool between the stakeholders involved [107].

Widely known business model ontologies are the Business Model Canvas [179], e3 value [108]; STOF [39], CSOFT [116], VISOR [79], and service ontology [112]. In Table 3.3 we present these six business model ontologies.

Table 3.3
Activities, and components that are included in the business model ontologies

Activities, and components	**Business Model Ontologies**
Value creation	e3-Value, STOF,VISOR
Value exchange on organizational level	e3-Value, STOF
Business model design	Canvas,e3-Value, STOF
Networks	e3-Value, STOF
Single service and/or product	STOF
Service bundle	STOF,VISOR
Product-customer segments	CSOFT
Design business models	Canvas, e3-Value
ICT services	STOF VISOR
Knowledge level	CSOFT

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Table 3.3 – continued from the previous page	
Activities, and components	**Business Model Ontologies**
Digital Services	STOF,VISOR
Innovativeness	CSOFT, VISOR
Platforms and technological architectures	STOF, VISOR
Viability	CSOFT, e3-Value, VISOR

As the table shows, most of the existing business model ontologies do not focus on the implementation, architecture, and technology. This was also noted by [229], who found that only a few business model ontologies pay attention to Information and Communications Technology (ICTs) or architecture. Exceptions are the VISOR ontology—where service platform is one of the elements [79]; and the STOF model, where the focus on technology is one of the four domains.

3.7 Business model Tooling

The focus with regard to the business models has moved from the reference models and ontologies to applications in IS [109]. One type of approach is the development of tools for organizational modeling or based on the above ontologies. Business model tooling [38] can test the feasibility of specific business models ([11], [67], [39]. However, little is known about how these tools can be used in practice. Furthermore, the existing tooling is more concerned with business model design than with business model implementation [67]. BMI requires a *'structure and guidance to frame and focus thought'* ([82], p.1325). A way to support BMI is with the use of business model tooling. Academics and practitioners argue that there is a need to switch from defining business models to the development of approaches analyzing business models ([39], [79]). Business model tooling can be used to support BMI. Academics and practitioners argue that there is a need to switch from defining business models to developing approaches for analyzing business models [67]. Literature is paying specific attention to developing business model tooling

[67]. Scholars and practitioners are interested in developing new business model tooling to contribute to the business model innovation process. However, the benefits of business model tooling are still not sufficiently studied [82]. Scholars and practitioners alike are calling for the development of [100] because '[...] *business models visualized using tools could serve as boundary objects between the stakeholders and the developers*' ([40] p. 152), and therefore, the development of practical tools to support business model innovation is necessary.

3.7.1 Business Model exploration and tooling

Here, we present our study on the exploration of business model tooling. We first discuss our approach and then the actual tooling and business model exploration. To understand the nature of the existing business model tooling and identify the gaps related to business model tooling for business model exploration, we conducted desk research on business model tools. We define business model tooling as tooling with specific input, specific output, and specific methodology to reach this output. We used the Google search engine, with key phrases 'business model tool', business model tools', 'business model tooling'. The search date was October 15, 2018, and we analyzed the first 500 results related to different business model tools. We created a database of tools that were referred to as tool/tooling for business models, and tools related to different fields of study that can also be used during the BMI too. For instance, tools created for enterprises' strategy can be used for BMI (e.g., SWOT analysis, Porter's generic strategies, PEST(EL) analysis). Tools designed for core business models are in line with the business models; as they were presented in the previous section (e.g., Canvas, STOF, VISOR) while supporting tools already exist (e.g., business model stress testing, road mapping, six thinking hats). We did not include in our database different versions of the same tooling or tools that referred to the same business model ontology (that was mainly the case with the Business Model Canvas). Our desk research led to 56 business model tools. Next, we evaluated how these tools can be used during the business model exploration process. Our desk research leads to 56 business model tools. Next, we evaluated how these tools can be used during the business model exploration process. Table 3.4 presents the results of our desk research.

Our desk research revealed that the existing business model tooling is mainly focused on how to design a single business model (e.g., [179], [39].[42]. On the other hand, a few tools are focused on creating alternative business models (e.g., business innovation kit, business model patterns cards; business model roadmap). Regarding exploration, a little less than one third of the tools' descriptions mention exploration, but in a different concept (exploration of ideas, understand the customers, understand the stakeholders, identify opportunities and threats). Tooling that concerns the evaluation or assessment of choices exists, but it is limited. What we can conclude is that the existing tooling can be combined toward a specific aim, for example, for the business model exploration process (e.g., the creation of paths with business models [117]). Based on that, existing tooling could be combined and used to support the BMI process. However, it might not always be possible to identify which tools can be used for the business model exploration process. Finally, from our desk research, we conclude that business model tools designed for technology disruption are not widely available. Thus, although tools for business design, testing, and implementation are emerging, tools addressing systematic business model exploration are lacking, especially in relation to disruptive technological innovations.

Table 3.4
An overview of available tools for business model and they relation with business model exploration.

Business model exploration	Business model tools
Experimenting with different business models/ alternative business models	business innovation Kit, VDMBee, business model patterns cards, business model roadmap, starter Kit, the rainforest canvas

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Table 3.4 – continued from the previous page

Business model exploration	Business model tools
Explore	business innovation kit, business plan, customer journey, deadly wastes canvas, empathy map, group map, marketing cards, minimum viable product (MVP), partner analysis, Porter's five force, return on investment, St.Gallen business model Navigator methodology, starter kit, SWOT analysis, value network
Sustain and develop	WOIS, VDMBee, Component Business Model, Critical Success Factors, Deadly Wastes Canvas, Partner Value Matrix, Persona, Pricing Strategy Cards, SWOT analysis, Value Network
Conceptualized business model	Business Model Stress Test, Business Plan, Canvas4Change, Collaborative Business Model, Component Business Model, The Rainforest Canvas, Thinking Hats
Initial business model design	Business Innovation Kit, Business model canvas, Business Model Metrics, Business Model Roadmap, Canvas4Change, Critical Success Factors, CSOFT, E3 value, Lean canvas, Minimum Viable Product (MVP), PESTLE Analysis, Value Network, Value Proposition Canvas
Explore new ways/make changes	BIZZdesign, Canvas4Change, Customer Exploration Map, Process Journey, Profit Calculator
VDMBee, New business model ideas; ideation	Balance Scorecard, Business Innovation Kit, Business Model Kit, Business Model zen Canvas, Focus Group, Group Map, Target Group Selection, Thinking Hats

Continued on the next page

Table 3.4 – continued from the previous page

Business model exploration	Business model tools
Making strategic choices; decision-making	Balance Scorecard, VDMBee, Business Model Roadmap, Component Business Model, Customer Exploration Map, Group Map, Marketing Mix
Assessing/evaluation	Business Innovation Kit, Business Model Wheel, Competitor Analysis, CSOFT, Customer Exploration Map, Customer Journey, Lean canvas, NOBEL GRID Business Model Evaluation tool, Personal Business Model, Porter's Five Force, Starter Kit

3.7.2 Business Model Tooling Functionalities

As revealed by our business model tooling exploration, many business model tools are available. Business models have come a long way since the first publications calling for attention to be paid to tools for BMI [208]. However, within both academia and practice, there is no clear agreement on which functionalities business model tools should have [208]. In this section, we discuss some of the commonly used functionalities we identified during our exploration, as well as functionalities that have still not been sufficiently addressed.

Patterns: One functionality that is now commonly used in business model tools are patterns. Patterns can describe proven solutions [13]. '*Business model patterns are commonly used and proven configurations of specific business model components*' ([147] p.21). These patterns are reusable and by rearranging one or more of the business model components, new business models can be created. Using patterns-based business model tools, users can develop alternative business models for the same value offering. The pattern functionality could be useful during business model exploration. Business model patterns can stimulate creativity and help overcome cognitive barriers during BMI, and that could contribute to the business model exploration and eventually to transformational change [57]. A negative aspect of patterns is that the creation of alternative business model combinations can be overwhelming [10]. An example of a pattern based business models tool is the ‘business model cards’.

‘Fill-in-the-blank’: Many business model tools follow a fill-in-the-blank approach, whereby users need to add information manually, and in some cases without really knowing what type of information is actually needed. The types of functionalities depend on the natural creativity of the user, as he or she does not receive assistance with using the tool creatively and filling in the blanks [208]. Typical examples of ’fill-in-the-blank’ business model tools are those based on the business model Canvas.

Evaluation/assessment: Another functionality that is not sufficiently discussed is the evaluation of business models. While in the literature we can find studies focusing on the evaluation of business models (e.g., [39], [118]), existing business model tools do not have features that support the evaluation of business model changes and alternative business models. Evaluation can take many forms, such as estimating costs and quantities, qualitative assessment, or improvement assessment [208]. An example of an existing tool that evaluates business model is the business model stress testing.

Apart from the functionalities that are commonly used for the design of business model tooling, researchers should explore additional functionalities and the extent to which these functionalities could be useful for the design of business model tools [208]. We address three functionalities that are not sufficiently addressed at the existing business model tools.

Element level business models: Another functionality that could be included and tested is the level of detail of the description of the business models. Existing business models tools (mainly those that follow the business models’ patterns) are focused on describing the business models as a set of components (e.g., distribution channel), rather than on a more detailed -level of elements (e.g., physical store and online store are elements under the distribution channel). An example of an existing business model tool that focuses on the element level business model is BizzDesign.

Predefined suggestions/templates: We define a predefined template that already has information available that users are able to choose from. Adding functionalities that increase idea stimulation could increase the usefulness of the business model tools [208]. In this case, the users do not create information, rather, it is ‘discovered’ from a predefined set of potential answers. This function could be supported by the use of business model patterns and is a potential way of applying the fill-in-the-blank approach. The predefined suggestion can be done with the use of a template containing predefined lists of potential elements that could fit specific components. An example of a business model tools that use the pre-defined functionality is the business model stress testing.

Domain specific: The final functionality that we did not identify in the existing literature on business model tools, is the development of tools for specific domains. Existing tools have different uses, and are created to be used by different enterprises and different industries; an example is the well-known Business Model Canvas, which has been used extensively in various cases. While domain-specific business models is a topic in the literature (e.g., Laurischkat et al wrote for a business model for electric mobility [140]), this functionality is not sufficiently addressed in existing business model tools. Future tools could address it and evaluate whether and, if so, how that functionality could be a useful addition to the list of existing business model tool functionalities.

3.8 Chapter Conclusions

In this chapter, we gave answers to the first research sub-question. We started the literature review by investigating the term 'business model'. We found that there is not a common way to define the concept and that scholars describe the business model concept with the use of different elements. We continued by investigating the BMI concept. Again, there is no consensus regarding the description of BMI; some scholars describe it as a process, others as an outcome. We adopted the first approach to investigate the BMI process when digital technologies innovations (as opportunities) enable changes. Investigating the BMI, we realized that the process can be described in different phases, with the business model exploration to be the phase that fits our scientific problem. Focusing on the business model exploration we understood that the concept is not sufficiently investigated and there is not a clear description of what activities are undertaken during business model exploration. Future step of our research should focus on identifying these steps. We defined business model exploration as the iterative process through which new business model ideas are created, conceptualized, and tested until a revised, alternated, and assumed a viable business model is achieved. To improve our understanding of the business model exploration, we investigated two practical cases. The cases revealed that enterprises do business model exploration, but they are not aware of it. Following the recommendations made in the literature, we continued exploring business model tools, arguing that it can support BMI. We reviewed existing business model tooling and found that it is mainly focused on design and that business model tooling for exploration is not available. Existing tooling still does not formally support the business model exploration of alternatives.

We concluded the chapter by discussing the functionalities (such as patterns, fill-in-the-blank approach, etc.) found in existing business model tools and what is missing. We identified that there is no clear answer to the question whether and, if so, how business model tooling actually contributes to BMI. Our review of business model tools showed that some functionalities are widely used (e.g., patterns, fill-in-the-blank), while others are not sufficiently studied/applied (e.g., evaluation functionalities, templates). The exploration of the functionalities served as the basis for the design principles. Although we described our approach in detail aiming to acquire a sufficient overview of the theories and the business model tooling, some literature or tooling functionalities may have been overlooked.

CHAPTER 4

DOMAIN [1]

[1]This chapter is based on: Athanasopoulou, A., De Reuver, M., Nikou, S., Bouwman., H. (2019). What technology enabled services impact business models in the automotive industry? An exploratory study. *Futures*, Volume 109, May 2019, Pages 73-83. 10.1016/j.futures.2019.04.001.

4.1 Chapter Introduction

The purpose of this chapter is to describe the domain for our research. Previously we identified the problem to be related to business models and disruptive technologies. In this chapter we discuss a specific domain, where disruptive technologies fundamentally change the industry and the business models. This industry is automotive. Next, we conduct exploratory research and we identify and discuss a specific technology disruption. This technology disruption is the Internet of Things (IoT).

The purpose of this chapter is instrumental. We use the automotive industry as our domain of research. Its mission is to show the impact of domain-specific tooling on the process of business model exploration. First, we articulate why from the plethora of industries by disruptive technologies we focus on the automotive industry. Then, we describe how the traditional automotive industry is changing because of the disruptive technologies and how it shifts to an ecosystem with flexible boundaries, new stakeholder and services that create both opportunities and challenges. We investigate the actors, the services and the prior business models. In our next step, we follow an explorative approach and we investigate how technologies are affecting the business model of the industry. We identify specific perspectives on how the services affect the business models and we reflect on specific technologies and services that create a large disturbance. Next, we identify the niche for our study and we discuss the decisions we made to make our research more focused, but at the same time possible to generalize. We discuss the IoT and how business models are reshaping due to the IoT. We conclude with a summary of the chapter.

4.2 Automotive industry

Ongoing digital transformation is considered an enabler for economic growth since the Internet boom of the 1990s, bringing with it disruptive change, increased interoperability and affecting the behavior of individuals, organizations and society [38]. Inevitably, various industries are affected by digitalization such as healthcare, manufacturing, agriculture and automotive industry. To decide on which industry we will focus on we identify three criteria:

The industry sector should:

- be of economic relevance;
- had stable business models until recently;
- have business models affected by digital technologies.

Automotive industry can be described as the set of enterprises that offer services and products related to design, manufacturing, and sale of commercial vehicles. Focusing on European Union (EU), the automotive industry provides jobs to 12 million people, accounts the 4% of EU's Gross Domestic Product (GDP), while it affects other industries such as ICT and mobility services [63]. Thus, we can argue that automotive industry is of economic relevance. Additionally, automotive industry is an interesting focus because the related businesses need to become more technology aware if they want to stay competitive [90]. Digital technologies are fundamentally changing the automotive industry and make the affected actors rethink their position in the market, and explore new opportunities improving their offerings [224]. The ongoing shift that occurs within the automotive industry from traditional car manufacturing towards digital platforms requires more understanding and investigation [63]. Enterprises within the automotive industry are in the process of rethinking and transforming their business from product to service-oriented enterprises [207], [228], [76]), and therefore their long established business models. Thus, we can argue that automotive industry, is affected by digitalization, and requires exploration of how established business models can be changed into service-oriented business models.

4.2.1 Offerings (From products to Services)

New technologies enable novel services allow the design and development of innovative, and customized mobility offerings (upon customers' requests and needs), such as mobility-on-demand, personalized driving experiences and advanced safety measures social media integration, enriched personal and vehicle experience, and alternative transportation models ([90], [142]). In that essence, the car can be seen as a platform that enables the development of a range of new value propositions leading to services the customers might want, need and might willing to pay for.

Identifying the services (and therefore the technologies that enable this) that affect the value propositions is interesting for our research as it allows us to focus on specific services and technologies that enable business model innovations. Additionally, the categorization is important for two reasons. First, due to the large amount of services, it is not feasible to investigate all of them one by one. Second Grouping them we can make generalizable conclusions relevant to larger number of services. Within the literature, the mobility-related services can be categorized in different ways such as based on the offering services [142], or based on the enabling communication [183]. Since no categorization was more service inclusive over another, we decided to conduct our desk research. We performed desk research (September 2016) from the publications that describe the categorization of the services as they provide an overview (and examples) of different innovative mobility-related services. As we were interested in innovative mobility services (that might not still be communicated in academic publications) we decided to collect information both from academic and commercial publications. More specific, we collated a significant amount of automotive-related services as discussed in academic (e.g., [183]) and commercial publications and white papers (e.g., publications from European Union, Deloitte, Accenture, IBM, FME, GSMA), as well as websites (e.g., Drive.com, techradar.com, phy.org). We explore publications via Google, Google Scholar, ProQuest and Science Direct. We had two rounds of desk research using deferent keywords. At the first round we used generic keywords as ['automotive industry' AND 'digitalisation'], ['mobility services' AND 'digitalisation'], ['transportation' AND 'future mobility trends']. From this round of desk research, we realized that new services are focused on autonomy, personalization, environmental impact, and connectivity.

For the second desk research we used itional keywords such as ['mobility services' AND 'personalization'], ['mobility services' AND 'customization'], ['mobility services' AND 'energy'], ['mobility services' AND 'environment'], ['mobility services' AND 'connectivity'], ['mobility services' AND 'sensors'], as ['future mobility services' AND 'personalization'], ['future mobility services' AND 'customization'], ['future mobility services' AND 'energy'], ['future mobility services' AND 'environment'], ['future mobility services' AND 'connectivity'], ['future mobility services' AND 'sensors'].

The initial research lead to 150 services. All 150 services were presented in a logical order, based on a qualitative clustering approach as proposed by [166]. This approach resulted in services related to:

- the use of autonomous cars (or driverless cars, self-driving cars) that 'support' the car to operate independently without the need for human input;
- connecting in-car as well as remote physical and digital objects to the Internet;
- the development of electric-or hydro-power cars designed to shift away from the use of fossil fuels and carbon gas emissions.

In the third step, duplicate services were removed from the list. We combined services with different names but similar or identical offerings. For instance, services described as driving performance, monitor vehicle performance, on-board diagnostics, and car maintenance diagnostics offer almost identical value to users; hence, we grouped them under the statement 'Driving performance'.

After discussions and evaluation with other researchers, next we reduced the number more by excluding services discussing futuristic concepts (services that cannot be offered with the current developments). Before we conclude to a final list we decided to represent equally the three main categories we find, that is services related to autonomy, services related to connectivity and services related to environment/energy. We conclude to 42 services formatted as self-explanatory statements, see Figure 4.1.

While this list is by no means a completed list of new mobility services (something not possible considering the vast amount of new technologies created and offered) we focused on having a representative list of services. The desk research allowed us to acquire a better understanding of new services and thus, value propositions. Next, we discuss how and if new mobility services change the way the offering is created, offered and delivered.

4.2.2 The changes in the automotive industry

In the previous section, we justified automotive industry as the domain of our research. This section describes the industry in more detail, how it is transforming into an ecosystem with flexible boundaries with old

New mobility related services		
The car is suitable for mobility-on-demand	Supplementary in-car entertainment services	Use of geothermal energy to generate electricity for cars
You can access a car whenever you like instead of owning one	Embedded Wi-Fi hotspot	Self-charging electric vehicles
The car learns the behaviour and preferences of the driver(s)	Full integration of smart devices	Electric car services
Car system is integrated with systems at home	Advanced navigation systems integrated into the car	Energy saving systems services
Real-time data processing	Driving performance	Hybrid car systems
Vehicle-to-vehicle connectivity	Health/ emergency related services	Eco-friendly car
Self-driving car	Localisation services	The car automatically joins a powertrain
Remote control services)	Automatic optimisation of travel time	The energy source switches to improve air quality
Driving-support systems services	Driving performance	Use of battery electric car
The car can sense its surrounding	Initiating actions through voice command	Use of noise reduction technologies
Vehicle-to-infrastructure connectivity	Remote maintenance management	Smart stop-and-go to save energy
The car is customised for disabled people	Information on the weather and outside conditions	Use of renewable energy sources
The car can take over from the driver when unsafe conditions arise	Pay-as-you-go insurance	Energy efficient designed car services that can contribute to the sustainable energy transition
Self-parking related services	Fatigue detection systems	P2P (peer to peer) service for charging electric cars

Figure 4.1

An overview of digitalization-enabled new mobility services.

and new participants. We continue with a description of the changing industry, the involved actors and the new offerings.

Digital technologies fundamentally change the automotive industry. '*Staying up to date with the technologies is crucial to the continued growth of the industry and its diversity, securing its future sustainability*' [63]. New services are emerging based on an interaction between vehicles (e.g., collision-warning systems), between vehicles and road infrastructure (e.g., road information), and between vehicles and devices (e.g., smartphone integration, payment, and even commerce opportunities) ([142], [183]). These services provide various types of information such as mobility information, infotainment, vehicle information, and Internet-related services [224]. These enabling new opportunities can trigger business growth, while creating new opportunities for partnerships in and out of the automotive industry's boundaries ([90], [224]). Due to that flexibility of the boundaries, automotive industry is moving from a well-defined and structured environment to a flexible networked ecosystem (i.e., a complex and interconnected system) with open boundaries [90].

Within this changing environment, new and old actors take place. Traditionally, Original Equipment Manufacturers (OEMs), suppliers and finance companies were the main actors of the industry. However, the shift towards mobility services is changing the industry, which has been historically structured with the car as the primary product, with. Currently, boundaries between actors are disappearing, and new entrants are starting to offer core mobility as well as auxiliary services based on consumer needs [90]. The traditional automotive industry actors' relationships were mainly one way with the customer to be at the last step of the chain as is can be seen in Figure 4.2.

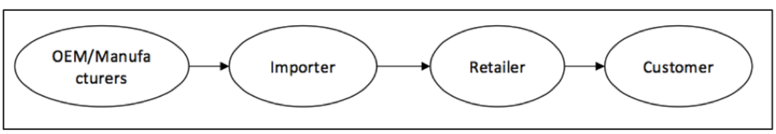

Figure 4.2
Traditional relations within the automotive industry [136].

However, from the previously well-structured industry where the car was the main product, and the car manufacturers and Original Equipment Manufacturers), were the main actors and decision-makers, the boundaries are fading and new entrants start offering services based on consumer needs [90]. In response to the shift to the automotive ecosystem, OEMs find themselves to seek collaboration with actors outside the ecosystem, while new actors are challenging the traditional business models of the industry [136]. Additionally, within the new automotive ecosystem, the needs of the customer are placed at the forefront. This leads to environments in which actors collaborate to develop new mobility offerings, in which possession of a car is less relevant than access to transportation means. Some of these new actors entering the boundaries of this new ecosystem such as auto-part suppliers, energy and fuel providers, system integrators, insurance companies, infrastructure providers, public authorities, and aftersales providers ([90] [151]).

In more detail, the main actors that are taking part in the new mobility ecosystem are:

Car manufacturers (OEMs): The initial actors and decision-makers of the automotive industry. Due to connectivity, the industry is changing to a mobility ecosystem and the manufacturers need to rethink their position in the market.

Auto-part providers: Just like car manufacturers, auto partners need to provide innovative products based on consumers requests.

Finance/Insurance providers: the connected car triggers questions on safety and security of the consumers. Insurance companies need to rethink their services and opportunities created by the trends within mobility.

IT providers: Internet and connectivity changed mobility. IT providers are new entrants that change the vehicle from being the main product to be a platform for add-on services. Software solutions are core focus for them. Apps developments, smartphone integration, car as a platform are core concepts and trends of the new mobility ecosystem.

Energy related services: Business within the mobility ecosystem currently focusing on providing services and products related to energy efficiency, sustainability and in alternative fuel. E-mobility and the production of eclectic vehicles are of ore focus with many companies developing electric car due to incising interest of the consumers and the need for relative infrastructure leads enterprises to rethink their business logic.

Peer-to-peer car-sharing: The concept of car ownership is becoming less relevant while costumers prefer shared on-demand services that are less costly and easily accessible by their smart devices.

Infrastructure providers: The new trends that are created due to digitalization and IoT created the need for new or advanced infrastructure like a new charging station for electric vehicles.

After sales providers: after sale focusing on providing services to consumers after they bought the product (in that case the vehicle). Due to the fast changing mobility industry after sale providers need to find ways on satisfying their costumers and gain their loyalty.

Consumers (Customers): Their role is becoming more prominent and there are considered co-creators of the mobility related products and services. Within the new automotive ecosystem, the needs of the customers are placed in the center of the interest for the automotive ecosystem actors. That leads to an ecosystem where actors partner with each other and form alliances to develop new mobility offerings for the customers. In other words, consumers are becoming co-designers of new services, and new entrants are offering innovative products and services. Consumers are co-designers for new services and new entrants are offering innovative products and services such as app driven electrical cars. Supplementary in-car entertainment systems (e.g., Apple CarPlay, Android Auto, and Google sponsored Open Automotive Alliance) like remote diagnostics, tracking and tracing systems and location based advertisement are already a reality. So, the car is becoming a platform on which add-on services run, see Figure 4.3.

4.2.3 Business Models in the Automotive Ecosystem

Traditionally, enterprises within the automotive industry possessed similar business models that followed a structured and linear approach for delivering a tangible product (e.g., vehicle) to the end user. Car manufacturers often have their own network of car dealers, leasing companies, and financing agencies. The primary business model for car dealers has been to sell cars, which are becoming more and more customized. Additionally, car dealers offer personal leasing to consumers, trade second-hand cars, and earn additional revenues from maintenance services and replacement of car parts. Upstream suppliers to car manufacturers range from providers of computer chips and software to providers of components such as bumpers, engines, and upholstery. The upstream suppliers have deeply integrated into the supply chain.

Disruptive technologies cause radical changes to the business models [188] and leads to business model innovation [63]. The role of technolo-

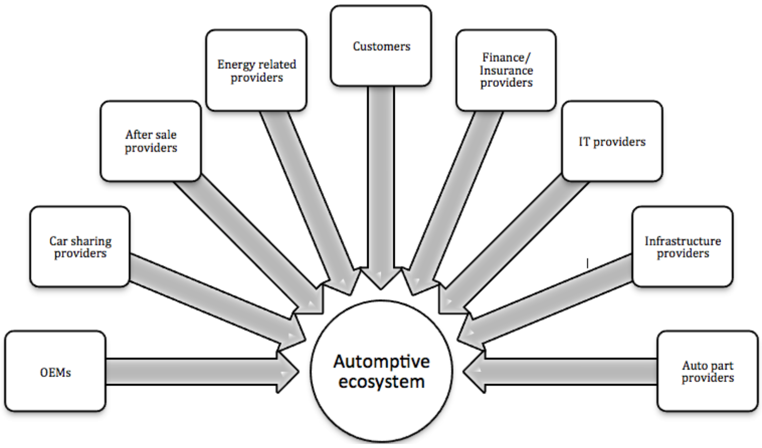

Figure 4.3
The independent ecosystem of actors within the automotive ecosystem (adapted from [90]).

gies for business models is twofold: new technology makes new business models possible, and innovative business models might require new technologies [61]. The technology-enabled services and product innovations offer new opportunities for value creation, which subsequently leads to new value propositions, requires new value creation activities, new partnerships, and asks for new revenue models of value delivery and capturing value actors within the automotive industry need to reinvent their business models [94]. Digital technologies disrupt the existing business models within the automotive industry [115]. There are three main challenges regarding business models within the automotive industry: (a) designing the new business models, (b) creating products or offerings of value, and (c) competing with the offerings of 'newcomers' (i.e., new participants entering the automotive industry after the technology disruption) (idem).

Business models adapted to the new digital services of previously physical offerings are required [89]. Currently, the existing and new participants of the industry, already offer new services ranging from navigation, via real-time traffic information, to in-car entertainment and whole fleet management programs, that require alternative business models as alternative business models. The car becomes an all-purpose transportation mean with add-on services and tailored solutions based on the consumers' needs [6]. Concepts related to IoT, self-driving, driving performance, mobility on demand and supporting services are considered that they will also change the operations of the enterprises within the automotive ecosystem ([6], [7]). Concepts such as self-driving, mobility on demand, and access over ownership are considered as concept with a high impact on the business models. These concepts will change the way personal transportation is organized and offered. Existing literature is concerned with emerging business models for the automotive industry, focusing on disruptive technologies and new offerings. For instance, Nickerson et al. [189] created a framework for car-sharing business models, as an example of servitization, and found that even the largest car-sharing companies follow different business models. Regarding electric cars, [135] developed a morphological box comprising a wide variety of business models concerning vehicle, battery, infrastructure and system services. Other researchers regarding electric cars propose different business models ([60], [140]), and connected cars (e.g., [21]).

However, literature on the impact of new services to the business model is rather abstract and most of the available conceptualizations do not explicitly link it with technological innovation and what services will enable rethinking business models. In the next step of our research, we analyze the expected impact that novel automotive services may have on forthcoming business models within the automotive industry.

4.3 Emerging services and their impact on business models in automotive industry

Services play an important role in understanding these linkages. Services are solutions to problems that users face, which may be enabled by technologies or other resources and competences. Due to new innovative and transformative technologies, innovative products and services are enabled, which in turn offer new opportunities for value creation, capturing and delivery. As services are enabled by technologies, innovative technologies become valuable once they enable new service offerings. To viably offer these services, business models are needed. As such, offerings are sustained by business models, and introducing novel services may necessitate new business models. In sum, technological innovations enable new services that in turn may require changes in business models.

However, not all of these services might require rethinking business models as new services do not necessarily require new business model. In this section, we aim to identify the expected impact that novel automotive services may have on business models within the automotive industry. With this study, we aim to reduce the complexity by distilling some high-level perspectives of services impact current business models and require the automotive industry to start reconsidering their business models. Based on that insight we aim to formalize the niche of our research. As we mentioned before, the automotive industry is experiencing a phase of rapid innovation, with emergent technologies underpinning the realization of self-driving cars, increased use of data and data analytics, sensors to enable car components to connect to the IoT and the use of alternative energy sources, such as electric vehicles. Such innovations enable novel services, which in turn profoundly impact the business models of actors within the automotive industry.

(Note: This stage of our research was conducted in 2016. Inevitably, innovations, services and changes that took place later are not included in this chapter.)

4.4 Method

We use the Q-methodology as our research approach, which is a qualitative method for identifying patterns in the opinion space of experts ([45] [218]). By experts, we mean researchers and academics in the field of automotive industry, mobility, and transportation. The method is exploratory and intended as a starting point for discussion and theory; hence it requires no ex-ante theoretical framework. Academic researchers specialising in transportation, and mobility form our pool of experts, the so-called P-set, and the opinion space is confined to opinions concerning how technological transformation of the automotive industry impacts the sectors services and subsequent business models. From this, we reflect on what can be the niche for our research.

Q-methodology, also known as Q-sort or Q-technique [74], is a research method that systematically focuses on human subjectivity [45]. Human subjectivity can be explained as the ways humans form and express their opinions and perspectives on a specific subject ([46] [5]). The fundamental basis of the Q-methodology is that while opinions are heterogeneous, possible patterns and structures can be identified. Q-methodology is used in various disciplines such as technology innovation [74], information systems [38] and transportation [218]. Q-methodology follows a different approach to traditional survey research, whereby the columns represent the participants (the '*P-set*') and the rows represent their opinions, behavior or attitudes (the '*Q-sample*'). Collecting these statements is a crucial task because the validity of the results depends highly on the '*representativeness*' of these statements (also known as concourse) concerning the subject under study. Hence, the Q-sample should be composed of different groups of statements, to ensure that each perspective is being treated equally.

Based on our argumentations on the previous sections of this chapter, we assume that service or product innovations mediate the impact of technological innovations on business models. Hence, our Q-sample comprises technology-enabled mobility services that may or may not affect business models in the automotive industry. Given the wide variety of mobility services, the Q-methodology is an appropriate approach for exploring patterns and reducing complexity in opinions. In this way, the method allows patterns to be identified that can guide our conclusions rather than evaluating each statement individually. One benefit of Q-methodology is that it identifies patterns present in a small sample of subjects. The identified patterns can be considered as common among similar people (target population).

4.4.1 Q-sample

An essential step in Q-methodology is selecting the statements for the Q-sample. Van Exel and Graaf [218] argue that a set of 40-50 statements is satisfactory. We describe this step as we described it in paragraph Services. The Q-set needs to cover the breadth of topics in the discourse, and overlap between items is, in principle, not problematic for the method. Yet, we combined duplicate services as much as possible such that we could cover the breadth of the 150 services found. A pre-test was executed to check the clarity and understandability of the statements and to obtain further feedback to avoid potential ambiguous expression and misinterpretation of the meanings. Ultimately, 42 services were selected that represent the broad range of core mobility and auxiliary services within each category. The statements on the services were rephrased to be as short and explicit as possible. Examples were added when necessary. To validate our findings, a pre-test was executed to check the clarity and understandability of the statements. Based on the pre-testing, we shortened the statements and added, if necessary, illustrative examples (see Table 4.1). The number of the statements (42) statements is acceptable as it follows the shape of a normal distribution [218].

Table 4.1
Statements and examples related to the identified services

Statements	Statements (con't)	Statements (con't)
The car is suitable for mobility-on-demand (i.e., urban car fleets located near strategically distributed transport hubs)	Supplementary in-car entertainment services (e.g., access to social media)	Use of geothermal energy to generate electricity for cars (i.e., energy generated and stored in the earth)
You can access a car whenever you like instead of owning one	Embedded Wi-Fi hotspot (i.e., the car can function as a hotspot to connect portable devices)	Self-charging electric vehicles
The car learns the behavior and preferences of the driver(s) (e.g., mirrors, chair, music preferences etc.)	Full integration of smart devices (e.g., smartphone, smartwatch, wearable)	Electric car services (e.g., EV rental services)
Car system is integrated with systems at home (e.g., the alarm is turned off when the car gets close to home)	Advanced navigation systems integrated into the car	Energy saving systems services
Real-time data processing (e.g., local accident information, information to avoid traffic jams)	Driving performance (e.g., on-board diagnostics, warning systems)	Hybrid car systems (i.e., combines a conventional internal combustion engine with an electric propulsion system)

Continued on the next page

Table 4.1 – continued from the previous page

Statments	Statments (con't)	Statments (con't)
Vehicle-to-vehicle connectivity (e.g., cars exchanges traffic information with each other)	Health/ emergency related services (e.g., e-call system, request for specific medical assistance)	Eco-friendly car (e.g., limiting CO2 emissions)
Self-driving car (e.g. car can drive without continuous attention from driver)	Localisation services (e.g., parking spot locator)	The car automatically joins a powertrain (e.g., cars with same speed and direction keeping relative distance)
Remote control services (e.g., software updates are installed remotely)	Automatic optimisation of travel time (e.g., based upon traffic jams, road conditions)	The energy source switches to improve air quality (e.g., car will switch to electricity in urban neighborhoods)
Driving-support systems services (e.g., vibrating the steering wheel if the driver loses focus)	Driving performance (e.g., on-board diagnostics, warning systems)	Use of battery electric car (i.e., use of chargeable batteries)
The car can sense its surrounding (e.g., can slow down on icy roads)	Initiating actions through voice command (i.e., hands-free calls)	Use of noise reduction technologies
Vehicle-to-infrastructure connectivity (e.g., the car communicates with traffic lights, pedestrian crossings)	Remote maintenance management (e.g., automatic scheduling of appointments based on in-car diagnostics)	Smart stop-and-go to save energy (e.g., turn car engine off and on at traffic lights automatically)

Continued on the next page

Table 4.1 – continued from the previous page

Statments	Statments (con't)	Statments (con't)
The car is customized for disabled people (e.g., accelerate with a button instead of feet)	Information on the weather and outside conditions	Use of renewable energy sources (e.g., air, solar)
The car can take over from the driver when unsafe conditions arise	Pay-as-you-go insurance	Energy efficient designed car services that can contribute to the sustainable energy transition
Self-parking related services (e.g., no driver input required when parking)	Fatigue detection systems (e.g., the car can detect if the driver is falling asleep)	P2P (peer to peer) service for charging electric cars (e.g., you can share private charging stations with other people)

4.4.2 P-sample

In Q-methodology, participants compare and rank-order opinion statements, forcing them to express their choice, feeling and/or underlying beliefs. This procedure is different from more conventional approaches, such as survey studies, which rely on rating each item in a questionnaire. To obtain meaningful results, Q-methodology requires a broad opinion space and a sample representative of richness of perspectives. Therefore, we select participants that have diverse involvement in the automotive industry, and who work on different technologies and areas of expertise.

We selected academics that research on innovative technologies or new ways of operating within the automotive industry. Academics may have a more comprehensive time perspective than practitioners and provide a greater overarching spectrum of ideas regarding the industry at stake, resulting in a broader diversity of opinions.

In selecting our participants, we face an important trade-off regarding their knowledgeability. On the one hand, we seek participants who have informed opinions on the impact of new technologies on automotive business models. On the other hand, especially insiders within an industry may be so immersed in an ongoing debate that they are disproportionally influenced by hypes and novelties within the sector. Hence, a limitation to be considered is that the more our participants are experts due to their immersion in the industry, the more they may be susceptible to trends and hypes of a temporary nature.

The participants were recruited from the network of involved researchers and participants at the 2016 European Association of Research in Transportation symposium. In the end, 30 participants completed the survey, which is an acceptable number in Q-methodology ([5], [226]). Participants vary in terms of research experience (83.3% with 3 to 10 years of experience; 6.6% over ten years (no specific answer given by 10%) and European region (South: 40%; Central: 30%; North: 10%), while 20% were non-Europeans. The majority of the participants (70%) work in another country than their country of origin. As we mentioned before the participants were recruited from a conference focusing on transportation. Therefore, the participants were academics in the transportation domain. More specifically, the participants indicated that their expertise is in the areas of traffic flow analysis, network design optimization, transportation choice modelling driving behavior, operation research, and traffic management. We attempted to control for knowledgeability of experts by explicitly asking them whether they are aware of new technologies, such as the Internet-of-Things, e-mobility, shared mobility etcetera. During these discussions, the researchers clarified the main concepts such as the IoT, shared mobility, and personalization. Several potential participants were excluded due to insufficient knowledge.

We informed the participants that the 'impact' relates to the extent to which business model components will change due to the services. We asked participants to rank the statements based on their personal opinion. We allowed them to change the scores throughout the process and explained that statements with similar meaning do not necessarily get similar scores due to the forced distribution. The statements had to be sorted on a linear scale, with high impact (+4) to no impact (-4) extremes. Statements in the middle of the scale are labeled neutral [217]. We used a paper and pencil approach: participants were asked to place 42 cards containing the statements on a hardcopy of the scale, see Figure 4.4 for an example. The principal author was present during the whole procedure and explained if required but did not intervene proactively. For instance, participants were encouraged to ask clarifications regarding the descriptions of the statements. To increase reliability, the researcher provided the same explanations to each participant.

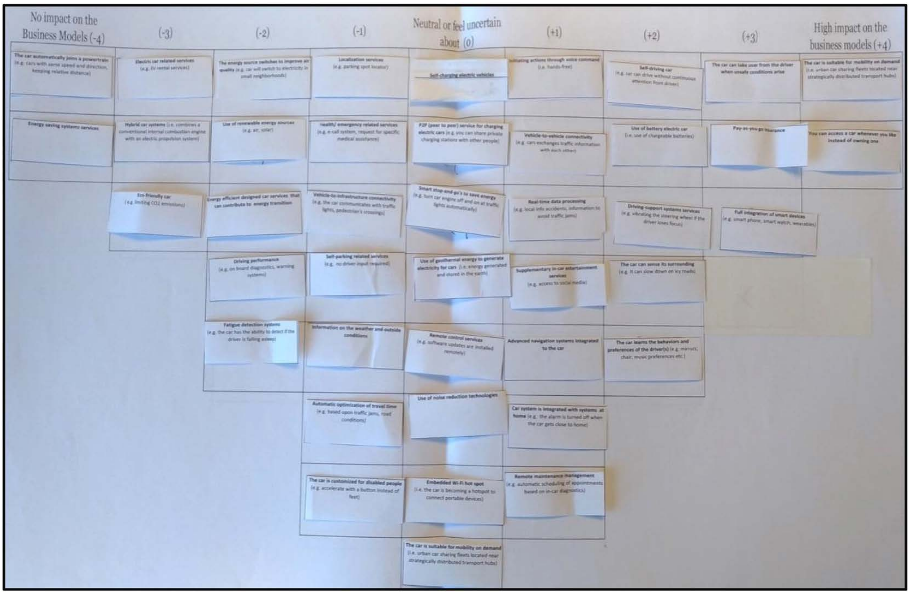

Figure 4.4
Pen and Paper approach: Participants were asked to place 42 cards with the statements on a hardcopy of the scale.

4.4.3 Data analysis

For analysis purposes, the ranking of statements by respondents is converted to numerical values [217]. Next, to identify patterns in the rankings of respondents and to reduce the complexity of the data, exploratory factor analysis is employed ([101] [24]). We used the statistical software XLSTAT, created as an add-in for Excel. Varimax rotation was applied to achieve an orthogonal rotation. We retained four factors with eigenvalues exceeding 1. The final step of Q-methodology is to classify the respondents based on their factor loadings. Following the formula from [45] significant factor loadings ($\alpha < .01$) should exceed 2.58*(1/N), N=42 (where N the number of statements).

Hence, factor loadings with an absolute value exceeding .39 are significant in our study. 30% of participants load in Factor 1, 10% load in Factor 2, 33.33% load in Facror 3, and 26.66% load in Factor 4. However, in case of participants load significantly on multiple factors, we retain only the highest loading factor [137].

4.4.4 Results

Table 4.2 provides the four factors resulted from the factor analysis. The rest of the subsections discuss the four perspectives that constitute the factors. Below we discuss the factors concerning perspectives.

Perspective 1: personalized services

Nine respondents hold the first perspective, represented by factor 1. This perspective (denoted as personalized services) ranks services highest that put the user central. The services that rank most positive are those developed for users' personal driving preferences and daily life (e.g., home systems integration). More specifically, respondents within this factor score positive on the personalization of the driving experience. Furthermore, the respondents highly rank statements regarding driving experience, such as voice commands, sensing of the surroundings and remote maintenance services: services linked to an improved driving experience. Low impact viewed statements were related to supplemental or add-on services like the integration of smart devices, embedded Wi-Fi connection, navigation systems and localization services. Also, negatively rated, advanced digital services are more 'general-purpose' services that are not tailored or personalized to the individual user. One could argue that this perspective favors services that put the user at the center rather than the car as a product. Hence, these services are expected to shift the core of value creation and capturing to servicing individual users rather than selling mass-produced cars or general-purpose services. In other words, this perspective relates to servitisation and improved user experience.

Perspective 2: generic mobility services

Generic technological developments of self-driving, smart device integration and electric cars score higher on the second perspective, represented by factor 2 (denoted as generic services), which is shared by three participants. More specific technologies like self-charging, decision making by the car and personalization rank the lowest. An interesting observation is that some of the low-ranking specific technologies (e.g.

decision making by the car) are enablers for some of the high-ranking ones (e.g. self-driving). A potential explanation is that experts with this perspective expect that broad trends (e.g. self-driving, smart device integration) affect the business model of the automotive industry, whereas the specific services enabling these trends (e.g. decision making by cars, smart stop and go) have a less direct impact. This perspective seems to emphasize that the major effect on business models will come from a change to self-driving, rather than specific technologies. The core of the expressed opinion is that self-driving, as an auxiliary service, will affect the business model of the automotive industry.

Perspective 3: shared mobility

The third perspective, represented by factor 3 (denoted as shared mobility) is supported by ten participants and represents a consensus towards the importance of shared mobility services. Statements that rank highly on this factor are mobility-on-demand, which was explained to respondents as the possibility to access vehicles that are stored in hubs nearby the user, and access over ownership, which is related to the idea of having access to cars rather than owning them. Other related services that rank high are pay-as-you-go insurance, self-charging and self-driving, which could be considered as enabling services for shared mobility, entailing less responsibility for individual drivers themselves. According to this perspective, the car is becoming less of property and more an enabler of a transportation services upon request. Lowest ranking services are related to energy efficiency, noise reduction, 'eco-friendliness' and energy savings. These experts hold the opinion that flexible mobile services on demand will affect business models most, whereas energy-related services will have a lower impact.

Perspective 4: connected cars

The fourth factor shows a strong preference of the experts for advanced services that allow cars to connect to each other and the environment, based on IoT capabilities. More specifically, this perspective shows a focus on services allowing communication between the driver, the car and its surroundings, for instance by the processing of real-time data. Highly ranked services are vehicle-to-infrastructure and vehicle-to-vehicle communication, advanced navigation systems, and travel time optimization. Autonomous driving and entertainment services do not receive high scores from this perspective, even though connected car services enable these. This fourth perspective also indicates that already available services such as voice command actions and embedded Wi-Fi are not considered to impact business models within the automotive industry. The highest impact on the business model is expected through product and service bundling, enabled by functionalities closely related to automated IoT infrastructure and communication services based upon, see Table 4.2.

Table 4.2
The four Factors.

Factor 1: Personalized services	**Factor 2: Generic mobility services**	**Factor 3: Shared mobility**	**Factor 4: Connected cars**
Highest impact			
Automatic adaptation to drivers' preferences (2.10)	Self-driving (2.20)	Access over ownership (2.73)	Real-time data processing (2.10)
Voice command actions (1.65)	Smart devices integration (2.01)	Mobility-on-demand (2.09)	Remote control services (1.60)
Surrounding sensing (1.62)	Entertainment services (1.34)	Self-charging (1.73)	Navigation systems (1.27)
Access over ownership (1.39)	Eco-friendly cars (1.01)	Pay-as-you-go insurance (1.62)	Vehicle-to-infrastructure connectivity (1.27)
Home systems integration (1.10)	Access over ownership (1.00)	Self-driving (1.52)	Vehicle-to-vehicle connectivity (1.19)
Mobility-on-demand (1.07)	Vehicle-to-vehicle connectivity (0.97)	Vehicle-to-vehicle connectivity (0.78)	Surrounding sensing (1.10)

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Table 4.2 – continued from the previous page

Factor 1: Personalised services	**Factor 2: Generic mobility services**	**Factor 3: Shared mobility**	**Factor 4: Connected cars**
Remote maintenance (1.03)	Real-time data processing (0.94)	Self-parking services (0.78)	Electric car services (0.85)
Self-driving (1.00)	Electric car services (0.92)	Vehicle-to-infrastructure connectivity (0.61)	Travel time optimization (0.81)
Lowest impact			
Fatigue detection systems (-0.77)	Smart stop-and-go's (-0.90)	Energy saving services (-0.82)	Home systems integration (-0.74)
Emergency related services (-0.84)	Outside conditions information (-1.00)	Renewable energy systems (-0.82)	Mobility-on-demand (-0.83)
Digitalised control panel (-1.05)	Decision making by the car (-1.02)	Smart stop-and-go's (-0.84)	Energy efficient services (-0.91)
Navigation systems (-1.18)	Disabled people customization (-1.17)	Hybrid car systems (-1.16)	Entertainment services (-1.20)

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Table 4.2 – continued from the previous page

Factor 1: Personalised services	**Factor 2: Generic mobility services**	**Factor 3: Shared mobility**	**Factor 4: Connected cars**
Powertrain join (-1.42)	Emergency related services (-1.33)	Eco-friendly cars (-1.20)	Noise-reduction technologies (-1.21)
Smart devices integration (-1.47)	Geothermal energy (-1.51)	Outside conditions information (-1.20)	Embedded Wi-Fi (-1.30)
Embedded Wi-Fi (-1.58)	Self-charging (-1.54)	Voice command actions (-1.46)	Remote maintenance (-1.94)
Entertainment services (-1.64)	Adapting in drivers' preferences (-1.55)	Noise reduction technologies (-1.47)	Peer-to-peer services (-2.08)
Pay-as-you-go insurance(-1.34)	Pay-as-you-go insurance (-1.58)	Energy efficient services (-1.57)	Voice-command actions (-2.35)
Note: standardised factor loadings between brackets			

4.4.5 Observations

From this stage of our research we identify four empirically informed observations regarding automotive service categories that are expected to impact business models in automotive industry. Having an interpretive view for our study, the below observations are '*own constructions of other people's constructions*' [178].

The four observations are: (1) enhanced personalization services to improve user experience in combination with servitisation, (2) generic mobility services, (3) shared mobility enabled by a combination of servitization and sharing, and (4) product and service bundling enabled by IoT based connected cars. On a more conceptual level, our findings show that business models in the automotive industry will be impacted by (1) servitization in general, combined with enhanced user experience, (2) auxiliary services of self-driving, (3) new mobility services, as a clear example of servitization, and (4) the bundling of products with IoT infrastructure and enabling services. These new service-based changes will, according to experts and academics, shape the future of the business models automotive industry.

Our applied Q-methodology allows for a more inductive, exploratory approach to describe distinct groups of mobility services. Reflecting on the perspectives elicited in the Q-methodology study, we can make some observations regarding the future of the business models within the automotive industry.

Observation 1: the elicited perspectives cover only part of the three broad technological areas (autonomous driving, Internet-of-Things, and e-mobility) that we identified at the start of the study (see Section 3). Autonomous (or self-driving) and IoT-enabled services are represented by a specific perspective. One of the perspectives elicited comprehensively covers the area of autonomous driving innovation. The elicited perspective on connected cars is related to the broader area of Internet-of-Things, as connected cars offer enabling services such as connectivity and remote data computing. Our findings show that there is no clear group of experts that think electric driving specifically will affect business models in the industry, which is in contrast with existing, technology-driven literature (e.g., [135]). These findings are significant as they imply that business model studies on the automotive industry should not necessarily focus on the three main technological innovations that industry reports currently focus on.

Observation 2: We find that servitisation is ingrained in two of the four perspectives, i.e., enhanced personalization of user experience and shared mobility. In the first perspective, personalisation services were also apparent, focusing on users rather than cars. The third perspective focuses on shared mobility. Both perspectives represent the trend from selling cars as a product towards offering mobility (on demand) as a service to individual users. For business models, both perspectives have major implications. Personalization represents a break in the automotive industry from a focus on high-volume customizable products towards individually tailored user experiences. Besides changes to the value proposition, also the delivery mechanisms, revenue models and channels change.

Observation 3: The perspectives represent different levels in which technologies become manifest. Only the fourth perspective of connected cars is focused on bundling of IoT based technology services: connectivity and data processing services. In two of the perspectives, technologies are not as explicit but are still clearly related to the services, as enhanced, personalised user experience and shared mobility are both enabled by technology. An interesting finding is that one of the perspectives clearly distinguishes higher-order generic services (e.g. self-driving) from lower-level enabling services (e.g. decision making by cars), even though these would logically contribute to each other. This shows a stark difference in how experts participated in this research project reason about technology, services and business models. The degree of technology-mindedness explains, to a large degree, these differences between perspectives, which in turn provides insight into the relationship between technological innovation, services and business models, highlighting differences in how experts reason about these dependencies.

Observation 4: The perspectives are useful for informing domain-specific business model tooling in the automotive industry. The perspectives can be used as a starting point for a domain-specific (i.e., automotive industry) business model innovation process, and more specifically to elaborate research from business model design (e.g. [10]) to the business model implementation phase.

Observation 5: The grouping by experts can be used for identifying domain-specific business model patterns or taxonomies in the automotive industry. The literature on business model patterns is currently emerging ([10] [190]), but they remain mostly unspecified for the automotive industry. Thus, the technology disruption that affects the automotive industry and the way they offer services urges mobility related enterprises to explore specific business model patterns based on their existing business models as well as their strategic choices.

Observation 6: The results indicate that there is no clear group of experts who expect the highest impact from energy or electric driving services. All services related to energy are ranked as having a low impact. This does not imply that these services do not affect business models, but only that other services will affect the business model more. Perhaps it is assumed that electric cars and future hydrogen-powered cars will induce only incremental changes such as replacing one key partner with another (e.g. petrol provider with an electricity provider) while the role of energy provider remains essentially the same.

The observations from this study allow us to gain a better understanding of the effects of technological innovation on business models in the automotive industry, and subsequently to formalize the niche for our study. Previously, we discussed why we choose the automotive industry as our main focus. The perspectives illustrate how experts have different perspectives on the abstraction level of technology-induced business model change. The observations we made allows us to make our research more focused on specific technologies and aspects related to business models that we can focus on the next parts, and formalize the niche of our research. More specific our observations indicate that a major technology that affects the business models of the evolving automotive industry is the Internet of Things (IoT). The observation regarding the dependencies clarify that the automotive industry that services, technologies and business models are dependent and changes to one bring changes to the other while the complexity is increasing. While we cannot focus on every technology that, from our research, we identify that will have an effect the business model of the automotive industry, IoT has a main contribution to the changing environment. Thus, we made the decision that for the rest of our study we will focus on the IoT, and investigate how IoT affects the business models of the automotive industry. As a result we decide to focus only at the case of the IoT as a technology that affects the business models within the automotive industry. Additionally, the IoT (as we will explain in the next paragraphs) On the other hand, the results indicated that technologies and services related to electric mobility and environment will not affect the automotive industry, and for that reason it was immediately excluded from the next steps of our research. Servitization is a major change and it is again connected to the IoT and it is an aspect that we will take into consideration related to the business models. Finally, the results indicate that we need to consider domain specific business models, and business model patterns. In the next sections we discuss the IoT from both a technical point of view, and business model point of view.

4.4.6 The Internet of Things (IoT) as a focus area

In this section we discuss the concept of the Internet of Things (IoT) from a technical point of view, and we discuss how business models within an IoT environment are. Firstly we discuss the influence of the IoT at the society and industry in numbers. Then we provide definitions and a description of what an IoT device is. We compare it with the 'traditional' Internet and finally we conclude with how business models change in response to the IoT.

Although the concept of IoT is emerging, a clear definition within the academic literature is still not available [37]. Kevin Ashton initially used the IoT as a term in 1999 at an oral presentation:

If we had computers that knew everything there was to know about things -using data they gathered without any help from us- we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best. We need to empower computers with their own means of gathering information, so they can see, hear and smell the world for themselves, in all its random glory. RFID and sensor technology enable computers to observe, identify and understand the world 'without the limitations of human-entered data.' Kevin Ashton (1999)

IoT is a '*dynamic global network infrastructure*' ([221], p.2) of digitalized and Internet enabled physical objects. IoT objects are emerging with a range from clothes (wearables) to vehicles (e-bikes, smart cars) ([168] [230]). The number of IoT objects is increasing year by year and already in 2017 the number reached 8.4 billion devices. From the numbers above we can understand the growing importance of the IoT for the economy, society and research fields. IoT is expected to change social and business processes, providing new possibilities [230] for industries to create new application (Chan, 2015), and change the way enterprises do business ([212] [138]). Existing literature is mainly concerned with the technical aspects of the IoT and less with business and managerial aspects [164].

IoT can be described as a major technology disruption. *'IoT is a network that connects uniquely identifiable things to the Internet. The things have sensing/ actuation and potential programmability capabilities.'* ([167], p.73-74). A main characteristic of IoT is that it allows physical objects to adopt digital characteristics [212]. IoT is not about a single novel technology but the combination of many complementary developments such as sensors, connectivity, and analytics. IoT is a major technology disruption because it implies that digital technologies will enter the physical infrastructures and physical product industries. Besides automating existing processes, IoT will enable collecting vast amounts of data and novel ways of actuating, which enable completely new ways of creating value. For instance, IoT enables remote monitoring of vehicle performance. That can enable anything-as-a-service business models [6]. IoT has the potential to transform the ways enterprises deliver innovation, improve customer experiences [44] faster handling, increased cost efficiency, process agility [214], and forecasting of stock situations [98].

While the IoT is spreading, the traditional and well-known business models' frameworks might not be in line with the IoT needs. *'To take advantage of new, cloud-based opportunities, today's companies will need to fundamentally rethink their orthodoxies about value creation and value capture'* [123]. IoT enables hybrid solutions of physical and digital services and that triggers revising the business models because physical and digital industries are not clearly separated [236]. Regarding, the IoT enabled services some challenges regarding business model can be identified regarding the design of new business models, how to create valuable products and services for the enterprises and the customers and how the enterprises can survive and compete due to the new entrants [185]. Other questions that arise are: How the actors will gain from the new capabilities? What new business model emerge, what should be change? How the enterprises will profit from IoT?

Scholars and practitioners define IoT in different ways (for some examples see Table 4.3) all the definitions have three elements in common: (a) the physical object (thing), (b) sensor(s), (c) connectivity. However, a unique definition is not available because when we are referring to IoT we do not mean a single novel technology but many different developments put in together to 'bridge the gap' between physical and digital word. That close relation with other evolving technologies such as ubiquitous communication, localization, ambient intelligence, user interfaces, makes defining IoT more challenging [144].

Table 4.3
Definitions of the IoT listed as defined by the authors.

Publication	Given definition
Xia et al. [234]	The networked interconnection of everyday objects, which are often equipped with ubiquitous intelligence.
Lopez research, [4]	IoT describes a system where items in the physical world, and sensors within or attached to these items are connected to the Internet via wireless and wired Internet connections.
McKinsey [6]	Sensors and actuators embedded in physical objects are linked through wired and wireless, often using the same Internet Protocol (IP) that connects the internet.
Minerva, Biru, and Rotondi [167]	Connectivity of physical objects (things), equipped with sensors and actuators, to the Internet via data communication technology, enabling interaction with and/or among objects (e.g., car, refrigerator, thermostat) that exists independent of IoT technology.
Oriwoh et al., ([177] p. 122)	The interconnection of objects or 'things' for various purposes including identification, communication, sensing, and data collection

For our study we adopt the definition given below [167] as it was emerged by a literature review of the previously published definitions:

'IoT is a network that connects uniquely identifiable things to the Internet. The things have sensing/ actuation and potential programmability capabilities. Through the exploitation of unique identification and sensing, information about the thing can be collected and the state of the thing can be changed from anywhere, anytime, by anything'
-IEEE ([167], p.73-74).

Any ordinary object can be become an IoT object with the addition of sensors and connectivity. The logic behind IoT is simple. More specific, in an object (i.e the thing) a sensor is added. This sensor collects unlimited data for something (e.g., temperature). Then these data are processed. Then, the reduced amount of data is then locally stored. At this point internet connection (connectivity) is needed. From this point the data are not collected, and processed locally but in a cloud able to share the data with the other objects at the network, see Figure 4.5.

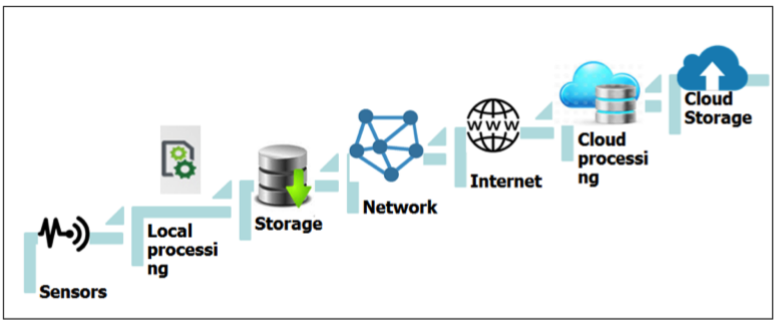

Figure 4.5
A step-by-step description of how an ordinary object becomes IoT.

To summarize, IoT allows an ordinary object that has some specific functions and interface to acquire intelligence in order to process and store data locally, to connect to the internet and communicate with other data sources in order to analyze data. Finally the users interact with the digital service that companies the previous layers.

The definitions indicate the three main characteristics of the IoT, that is sensors, objects and connectivity. For the connectivity Internet connections is needed. That means that the IoT is not a '*competitor*' to the (traditional) Internet, but an improvement. To make it clearer, in the traditional Internet the content is created by humans while at the

IoT the content is created by a machine (e.g., a sensor that measures the temperature). At the traditional internet this consent is '*consumed*' upon request (e.g., a Google query) while at the IoT the content is consumed when an action is triggered (e.g., change at the precipitation). While at the (traditional) Internet that content is connected via hyperlinks at the IoT the content is connected via the detection of specific actions (e.g., movement sensors). Finally, the added value of the traditional Internet is answering queries while the added value of the IoT is to provide timely actions and notification for specific actions, see Table 4.4.

Table 4.4
The differences between the (traditional) Internet and the Internet of Things (adapted from [83].

	The 'traditional' Internet	**The Internet of Things**
Who is the 'information' creator?	Humans	Machines
How the 'information' is consumed?	Upon request	Triggering actions
How the 'information' is connected?	Using physical (hyper)links between webpages	Detection of specific situations
What is the offering value?	Answering queries	Timely actions and notifications

Enterprises are developing IoT-related services, products and applications [130]. A main characteristic of IoT is the intermixing of physical products and digital services [33]. This intermixing allows physical objects- to adopt digital characteristics [212].

We provide more details for the five layers architecture provided by Bilgeri et al. [33].

Physical Thing: An ordinary physical object with some specific uses that is not a computer, without intelligence that directly interacts with the user.

Sensor: In the next layer computational intelligence is added to the physical thing. This computational intelligence can be a minicomputer, microcontroller or sensors. This computational intelligence is used to improve the functions of the physical thing. To do what it used to do but better. This add on computational intelligence operates in a local level, by collecting vast amounts of data processing and storing them locally.

Connectivity: In the next layer the thing becomes connected to the Internet. Adding connectivity the previous layers are becoming accessible online and remotely. That allows functions of the physical thing to be leveraged and new services to be added.

Analytics: The computational intelligence and the connectivity make the physical thing smarter but it does not generates added value. To do so, in that layer the collected data need to get analyzed and synchronized with data from other sources (e.g., cloud). In a next step, this data can be synchronized with other data from various sources.

Digital Service: the previous layers are combined together in the last layer. These digital services are combined and offered to the uses in different formats such as mobile apps. See Figure 4.6 for an overview of the IoT specialized business model.

The figure indicates that IoT requires business model exploration. However, innovative business models can include both new and traditional elements. At the same time there is not a specific fit-all business model business model and that drives the need for additional exploration of the business model.

Key partners	Key activities	Value propositions	Customer relationships	Customer segments
Hardware producers Software developers Data analyst Device Manufacturer Other suppliers Data interpretation Launching customers Distributors Logistics Service partners Partner network IT suppliers Development partners Customers	Product Development Platform Development Partner Management Platform and resource Integration ability Customer development Implementation: Service Marketing: Sales Platform Development Partner Management Software development Logistics	Newness Performance Customization Convenience Share Product/process optimization New product/service/ solution offerings Data mining	Communication Fast feedback Intensification New contact persons Longer term relationships	Mobile Users Companies New customers in new industries New customers in existing industries
Cost structure	**Key resources**	Revenue streams	**Channels**	
Product development cost IT cost Infrastructure Personnel cost Hardware/production cost Logistics cost Marketing & sales cost Production	Intellectual property Employee capabilities Information Software Relations Customer Resource	Usage fee Subscription fees Start-up fees Installation fees	Direct sales Indirect sales	

Figure 4.6

Example of a IoT specialized CANVAS business model.

4.5 Chapter Conclusions

The purpose of this chapter was to identify the niche for our study, that is the influence of IoT to the business models in the automotive industry. We explain in more detail aspects important for the research and therefore this thesis.

We did an explorative research (Q-methodology). This study explores what types of technology-enabled services have the most significant impact on current business models within the automotive industry. We found broadly four perspectives on mobility services that experts believe to affect business models: personalization and enhanced user experience services, self-driving, mobility-as-a-service, and IoT-enabled connected cars. The elicited perspectives show the relevance of servitization, service bundling and auxiliary services in understanding how business models in the automotive industry will change. Additionally, such understanding informs practical tools for designing business models. Regarding the results, a limitation of this chapter is the sample as the specific group of academic experts might be more technology-oriented than business researchers. However, as technologically advanced services only compose one of the four elicited perspectives, we consider this bias as marginal.

A limitation of our research is related to the term 'impact'. We are aware that *'impact'* can take multiple forms: from a single change improvement at a business model component to a change of the whole architecture. Also, an impacted business model does not necessarily imply that the old business model has become obsolete, but rather that it is likely to be subject to change. However, in the empirical part of our research we did not distinguish the different forms. The different forms of impact could be tackled in future research.

A limitation in any Q-study is that the number of items has to be constrained to a number that is feasible for participants, typically 40-50. Therefore, for instance for the perspective of shared mobility, our set contains certain dimensions (e.g., access to cars instead of ownership, availability of cars in nearby hubs) but not others (e.g., ride sharing, ride hailing). Another limitation of the study is the sample. The specific group of academic experts might be more technology-oriented than business researchers. However, as technologically advanced services only compose one of the four elicited perspectives, we consider this bias as marginal. Another limitation may be that new services may emerge in the coming years that lead to new insights and opinions.

We reflected on the results of the Q-methodology and made six observations regarding the future of the business models within the automotive industry. These six observations 'shape' our research niche. Based on the observations, we explicitly focus on the IoT, as the technological disruption that affects the business models, as it is a technology that is expected to fundamentally change the mobility and thus the automotive industry, and the business models. The expert views elicited in our exploratory Q-methodology differ significantly from classifications mentioned in the popular press and technology-oriented academic literature. However, other researchers could present the results in a different way that might lead to a different number of observations, or in a different way of describing them. After many iterations we concluded on these six observations that were the more inclusive that help us to shape the niche of the study. In the next chapter, we present the next step of our research were we do an exploratory research, based on the niche, to identify the design principles for the design of the artifact.

Chapter 5

Design Principles [1]

[1]This chapter is based on: Athanasopoulou, A., De Reuver, M., The role of tooling and agility in business model exploration: Evidence from action research, submitted in special issue on Business models and tooling, Electronic Markets, *under review*, and
Athanasopoulou, A., De Reuver, M. Roelfsema, M., Kosman, R (2018) Understanding business model innovation in practice: Recommendations for future business model tooling by an action research. In Proceedings of R&D conference, Milan, Italy.
This research took place under EIT Digital-Digital Cities Action Line (activity 17091).

5.1 Chapter Introduction

In this chapter we address the second and third research sub-question: *What activities are undertaken during business model exploration?* (RQ2). and *What are the design requirements for designing tooling that supports the business model exploration activities?* (RQ3) The aim of this chapter is to identify, discuss and suggest a set of design propositions for the design and development of the digital-based tooling for business model exploration. First, we collect data from empirical research where we use action research as methodology. From this empirical study, we want to investigate how existing business model tooling facilitates the business model exploration. From this process we create a set of lessons learned that could be used for the design of future business model tools. We collect the data by actively participating in the European Union-funded project, regarding technology-driven service design for improved mobility. The recommendations are used as inputs for the creation of the design principles, and subsequently the theoretical framework.

The chapter is structured as followed. First, we discuss the action research project, that we participated and the analysis of the results that formulate the recommendations for the development of future tooling. Next, we discuss how these recommendations derive the design propositions development. The chapter concludes with the summary of the design principles and the answer to the third research question.

5.2 Chapter Methodology

We use action research as our research approach. Action research allows researchers to develop and test theoretical ideas on the efficacy of specific actions, through a process of interacting and intervening with practitioners in a naturalistic setting [26]. As our focus is on examining the iterative and agile process of business model exploration, including the interaction between different design teams, action research is particularly appropriate. Action research is suitable for our purposes since it allows applying interventions (i.e., business model tools) in a real-life setting (i.e., a project aimed at opportunity creation) throughout a long-term and unstructured process (i.e., business model exploration).

For that step of our research, we opt for action research rather than action design research (a approach that compines DSR and since we do not aim to create an artifact. Similarly to action research, action design research focuses on solving a practical problem, with researchers and practitioners working closely together in iterative cycles [194], in order to generate knowledge [62]. The main difference is that action design research generates design knowledge by *'building and evaluating ensemble IT artifacts'* cycles [194]. Yet, in our case, we develop a business model, which we view as a constructor idea without any intrinsic IT component. Therefore, we use action research rather than action design research as our methodology.

We structure our research based on the action research cycle provided by [206], comprising steps of Diagnosing, Action Planning, Action Taking, Evaluating, and Specifying Learning, see Figure 5.1. According to [25], the research environment of action research is constituted by a client-system infrastructure. Two types of actors take part: the researchers and the practitioners (the 'clients'). This client-system infrastructure allows the collaboration between the researcher and the practitioners with mutual interest [26].

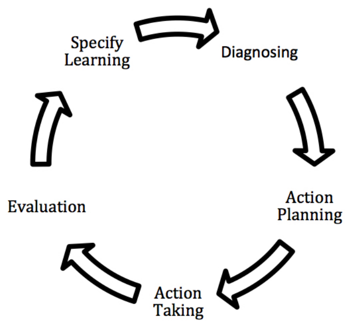

Figure 5.1
The Action Research (based on Susman [206].

For our research we focus on an innovation project conducted by four businesses and one university, taking place in 2017. The project is partly funded by an independent organization of the European Union, and partly by the businesses involved. The project aimed to discover and exploit opportunities aimed to create a commercially viable product and a start-up to offer the created product. Within the project, five organizations collaborated in order to develop and test a product and underlying business model. In this way, the project fits the notion of opportunity-driven business model exploration as conceptualized in chapter 3.

We participated in the project (as researchers) as we '*diagnosed*' the problem, we '*planned*' and '*took*' specific actions, we '*evaluated*' the outcomes with the project partners and finally we 'formulated' what we learned from this process. That allowed us to actively intervene, collect data, and gather feedback. The project partners were meeting monthly in a face-to-face or online setting to discuss updates and arrange action points for next month. Between the official monthly meetings, bilateral meetings were held between partners when necessary. Other activities included the promotion of the project in European events, focus groups with potential users, workshops evaluating the products and interviews with potential stakeholders.

Commonly in Action Research, theory is used to develop working hypotheses that inform the interventions to be taken [26]. We derive the following working hypothesis:

Business model tooling facilitates business model exploration leading to new business model ideas.

5.3 Research Setting

The project takes place within the mobility ecosystem. The overall purpose of the project was to create a start-up that promotes a road safety culture and makes sense of attitudes and choices, thus allowing both young people and mobility stakeholders to get a deeper understanding of the '*why?*' behind risky driving behavior. The initial goal of the project was to build and commercialize something that stimulates safe driving behavior by young people. Ideas to achieve this goal were to create online communities of young drivers, to model driving behavior, using data collected from the communities, and to use gamified systems to train young people on road safety. However, within this broad scope, a clear overview was lacking in what the final product would be and what problem that would solve for which customers. Based on the initial plan, the ultimate goals for the project were: **(1)** a product described as a digital toolbox that improves the road behavior of young people, **(2)** creation of a start-up that offers the developed product.

The research setting involved five organisations: *one university* (The Netherlands), *one public research and innovation institute* (Italy), *two private consultancy companies* (The Netherlands and France), and one *private research and design studio* (Italy). At the initial project meeting, the responsibilities of the partners (researchers and clients) were defined (see Table 5.1). While the university and dutch consultancy firm specializing in business model research, the other three project participants had no experience in designing business models. For a period of 12 months (January-December 2017), the consortium project partners participated in various activities.

The final product of the project was a 'toolkit' including **(a)** a website with the main aim to create a community that will share their ideas and feedback on the topic of driving safety, and **(b)** an engaging 'gameful' app that gathers information (taking advantage of the IoT) about decision-making and attitudes in a structured form (data) from young people in a gamified way.

Table 5.1
The teams of the project and the assigned tasks.

Teams	**Tasks**	**Organizations involved**
Management	Project management, Communication and Dissemination, Product user evaluation, Start-up creation	Public research and innovation institute
Business Model Team (part of this team where the researchers)	Market research, Business Modelling, Mock-up business evaluation, Product business evaluation	Technical University, Private consultancy company (The Netherlands)
User research	User engagement, User analysis, Mock-up user evaluation	Private research and design studio, Technical University
Design and Development	Product design, Product implementation, Product user evaluation	Private consultancy company (France), Technical University

5.4 Data Collection

To increase the validity of our research we document our actions in a logbook. Key informants (project partners and other involved individuals) validated the interviews transcripts, minutes from meetings and workshops, where open discussions followed each presentation. The official deliverable (mandatory) describes all the activities we undertook related to business models.

Table 5.2
Data Sources.

Data sources	**Amount of produced documents and pages (Pages are indicated when applicable.)**
Email messages on business model exploration	365 (related to business model topics)
Minutes from interviews with potential stakeholders and customers (e.g., driving associations; municipalities, insurance companies)	13 documents (39p)
Minutes of project meetings	12 documents (66p)
Workshops with project partners	4 documents
Presentations with intermediate results	9 documents
Official deliverable regarding business model exploration	1 document (16p)

5.5 Analysis

5.5.1 Step 1:Diagnosing

During the diagnosing phase (*Month 1-2*) the collaboration with the other project partners was intensive. Physical and online meetings, presentations, discussions and brainstorming sessions took place throughout the diagnosis. The partners had a set of underlying assumptions on the broad problem that the innovation project should address: mobility behavior is difficult to capture among young people because they are more reluctant than adults to be monitored through connected devices. In case sensing technologies are in place and accepted by young drivers, collected data tell what happened (e.g., driving style), but not why it happened (e.g., perceptions, norms, and beliefs affecting driving behavior). Participants also agreed that the ultimate product should leverage existing technologies and knowledge they had developed in research-focused projects, such as gamification approaches and psychographic models on norms and beliefs affecting the driving behavior. However, apart from this generic problem awareness, the project participants did not know yet what the final offering should be nor could they envision a business model for the start-up. In this way, our initial diagnosis fits the idea of opportunity-driven business model exploration. The initial diagnosis indicates that a start-up should be launched as a prerequisite of the funded project, based on a viable business model, and the offering and target group are not defined or developed, and hence, it is difficult to define one specific business model.

5.5.2 Step 2:Action Planning

Next, we planned specific actions (*Month 2-5*). These actions were derived from the diagnosis phase and informed by the working hypotheses derived from theory. We planned to take these actions throughout the period we had, solving the problem we diagnosed towards the overall aim of creating a startup.

We collaborated with the practitioners to plan a specific set of activities to take towards the desired future state, that is, the release of the start-up (*Month 12*). First, we separated the responsibilities of the different partners. Then, we decided to use the business model tools and in close collaboration with the partners to:

- investigate what the potential entering markets could be,
- identify who the potential competitors are,
- design potential business models and discuss the building blocks that are missing,
- create potential business model scenarios,
- include in the discussions potential stakeholders,
- plan feedback session from potential users,
- discuss with potential users and stakeholder what a valuable product could be,
- discuss potential revenue models and the risks of the different models, and
- develop the business model in parallel to the product and other activities of the project.

Figure 5.2 presents the initial division of responsibilities. The dashed shapes indicate the activities for which we were responsible. The figure illustrates the agile approach we followed where the different partners were working in parallel for their pre-specified task(s). The results of the task planning were discussed with all the other partners.

A core planning decision is what business model tools to use. Since we aim to generalize to business model tools, we decided to use a broad portfolio of tools, covering the diversity of existing tools. We selected tools covering the different processes of business model exploration: ideating, envisioning, reframing and action-formulating. We also selected tools with diverse focus: tools that cover the business model as a whole (e.g., business model canvas) and tools that focus on one specific business model component (e.g., value proposition canvas). Finally, we selected tools with different forms: cards, canvases, checklists, and process descriptions. With these minimum criteria for coverage in mind, we selected tools according to the needs in the action setting. For coherency purposes, we selected tools from an available repository of tools (businessmakeover.eu).

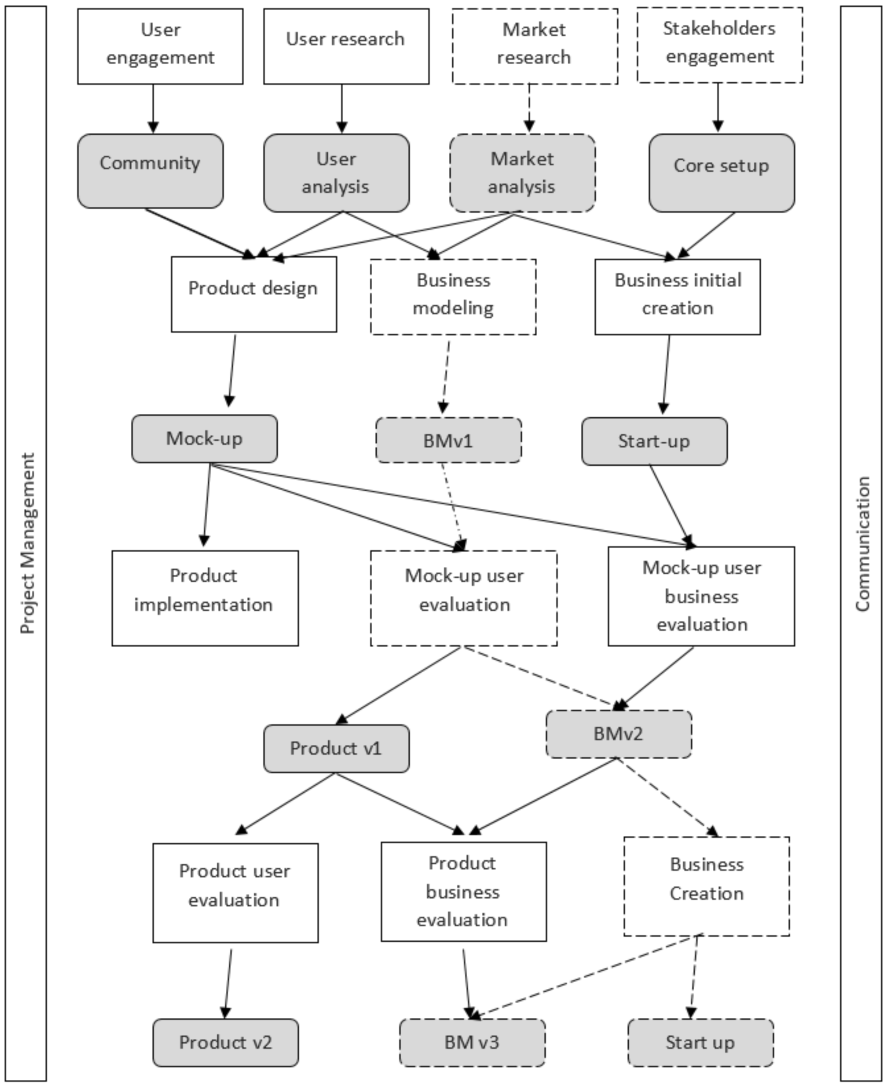

Figure 5.2
Initial division of responsibilities.The dashed shapes indicate the activities for which we were responsible.

The business model tooling we used is: (a) Persona-organisata: (b) Business model Canvas tool; (c) (parts of) STOF Business Model, (d) Focus Group (e) Business Model Cards; (f) Competitors analysis, (g) Thinking Hats (h) Business Model Roadmap (i) Pricing strategy cards (Business Makeover, 2018). Table 5.3 presents the business model tooling and the business model needs we used them for.

We applied the business model tools in an iterative and agile approach, going back and forth between the business model, design and user teams. In some cases, tools were applied through workshops that took place with the partners. In most cases though, the researchers interacted with the other teams through meetings and semi-structured conversations to distill information needed to fill out the tools. The distilled information was then rationalized into, for instance, a filled out template or canvas. The results were then fed back and discussed extensively with the other design teams.

There were several instances in which the interaction between the design teams affected the substantive choices in the project. For instance, the initial business model workshop held with project partners led to four scenarios for how the company could create value: offering access to a community of young drivers, selling a gamification toolkit, collecting data on driving style, and changing the behavior of users such that safety is promoted. After discussions with project partners, the fourth scenario for the value proposition was removed from the project scope since this was considered infeasible technically. The business model development task hence helped to focus the product development on those features that provide a unique positioning in the market.

As another instance, we present how we used the Business Model Canvas tool. We used this tool to create alternative business models based on different scenarios. We then, concluded to three alternative business models (see Figure 5.3). Then, we presented the alternative business model to the project partners. They rejected one of the business models as not feasible, they made some recommendations and then, we revised the business models. After multiple iterations and discussions between the product and business model teams, we revised the business models until we reached a final business model for the startup (Figure 5.4).

Table 5.3
The business model tooling we used.

Tool	Business model exploration process	Type of tool	Scope of tool	Purpose in the action setting of using the tooling
Persona-organisata	Ideate	Process description	Specific component	Identify potential customers for the offerings
Business Model Canvas tool	Ideate	Canvas	Business model as a whole	Initial design of the business model. Revision into multiple alternative versions, to reflect the changes made in the product definition
STOF Business Model	Ideate	Checklist	Business model as a whole	Collect ideas of project participants for the initial version of the business model
Focus Group	Envision	Process description	Specific component	Evaluate potential product features with prospective users (i.e. young drivers).
Business Model Cards	Envision	Cards	Business model as a whole	Identify potential revenue models
Competitors analysis	Reframe	Canvas	Specific component	Analyze existing offerings in the market and map them as competitors
Thinking Hats	Reframe	Process description	Business model as a whole	Identify stakeholders that might be affected by or become a customer of the offerings
Business Model Roadmap	Action-formulation	Canvas	Business model as a whole	Create a practical action plan for launching and scaling up the future start-up
Pricing Strategy Cards	Action-formulation	Cards	Specific component	Develop alternatives on pricing models

Figure 5.3
The use of the business model CANVAS for the creation of alternative business models (Osterwalder and Pigneur, 2010;). We used the online tool available via businessmakeover.eu.

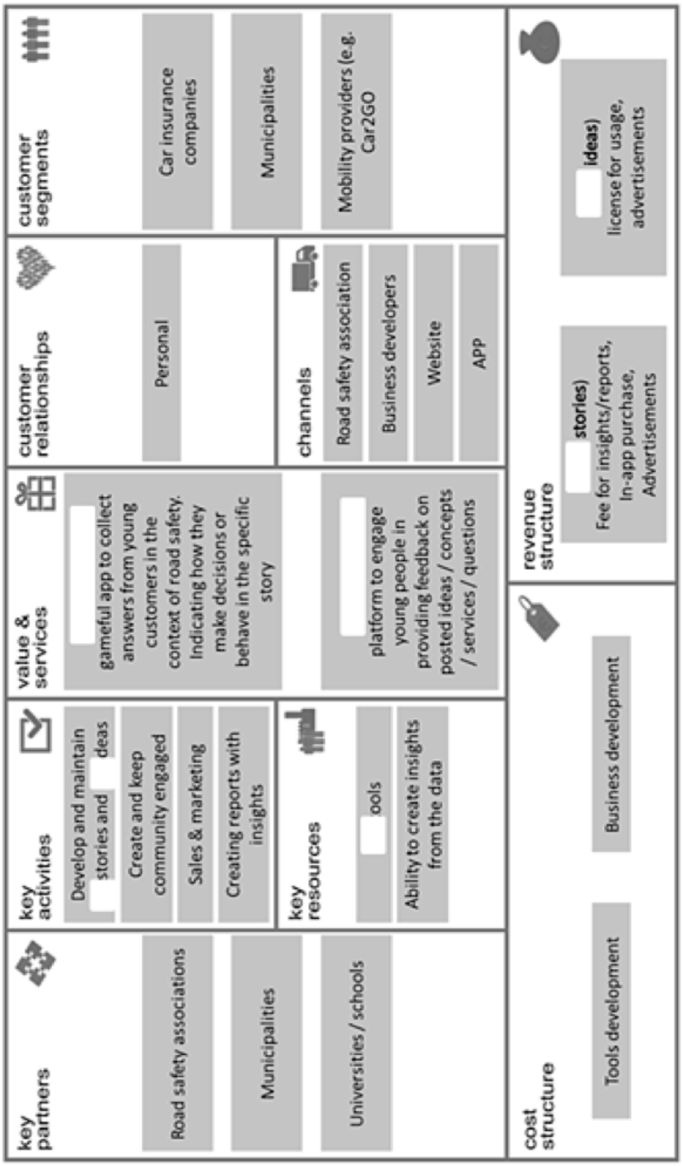

Figure 5.4
The final business model Canvas after iterations (Osterwalder and Pigneur, 2010). We used the online tool available via business-makeover.eu). For privacy reasons some text is removed from the photo.

5.5.3 Step 4: Evaluation

As part of the project, a start-up has been initiated that will exploit the results. Based on the business model development results, finding a viable and scalable business model was still a challenge, and would require continued interaction with stakeholders. Several scenarios were explored through interviews with various paying customers, from insurance companies and parcel delivery companies to municipalities and road safety associations. Initial evaluation with stakeholders shows that in principle there is interest in the offerings.

A challenging part of this project was that the offering was not clearly defined up-front. Adaptations of the business model design were needed to align with the final product definition. Also, there were many degrees of freedom in defining the business model considering that there was no launching customer defined yet, which created room for creativity but also a wide-ranging set of business model designs. To come to a specific offering a lot of iterations and discussions were needed.

Our approach led to a few cases in which the activities performed by the business model team gave a 'push' to the other teams to make decisions regarding the offering. For instance, the creation of different potential business models triggered the design team to make an overview of potential offerings. The market and competitor research was instrumental for finding out the competitive edge of the offering and thereby steered the product development. When the results were presented to the other project partners, a discussion among the teams was held where some of the business models were rejected and others were preferred.

The business model tools were useful especially when the business team wanted to communicate ideas to the other partners or stakeholders. The use of the tooling helped to make the business model design more specific. Developing the product and the business model in parallel resulted sometimes in challenges. The product was not clearly defined in the early stages of the project; hence, the initial business model designs do not fully match the final product. Adaptations of the business model design were needed in order to align with the final product definition.

One more challenge is that there was not always a clear distinction between paying customers and end users. Early in the project, it was clear that these the role of the (paying) customers and users roles should be separated as young drivers are not willing to pay; however, the available tools do not always make such distinction. Another challenge was that the business model tools are not made for businesses that are still exploring. Multiple versions were needed for alternative business models and value creation approaches. Active and iterative business model experimentation was needed as the offering was not clearly defined and new technologies enabled new value propositions.

5.5.4 Step 5: Specifying Learning

While specifying learning is the activity described the last, in practice, it was an ongoing process. We first reflect on the knowledge useful for the client organizations (in our case the project partners). The collaboration was based on an opportunity (funding, societal impact, exploitation of technologies). However, the final offering was not clear. What we learned was that when the offering is not clear, the potential stakeholders, customers, and target group are not clear either. Project partners were asking the researchers to suggest a business model, whereas this was challenging without a specific offering. While we did not fully answer to their request, we created an initial business model that was adopted throughout the project. From the whole process, we realized that the business model exploration is becoming more focused when there is an initial business model to work upon. The initial business models allowed iterations that provided advantages. For instance, the market and competitor research was instrumental in finding out the competitive edge of the offering, and thereby steered product development. These advancing decisions were each time reflected in updated versions of the business model design.

We learned that when the offering is not clear, alternative business model scenarios are needed. Exploring the alternatives can give some ideas and reduce the possibilities when one idea is not feasible. That helped project partners realize that they did not need to focus only on the 'obvious' customer groups. Customers from other fields are possibly interested in the product as well. Something else we learned from the process was that updates and revisions to the business model are important when new outcomes are available from other tasks. Hence, business model iterations are required when opportunities are created. Revisions and flexibility are important when experimenting with business models.

Using business model tooling from the start allows identifying questions that need to be answered, thus providing more direction in subsequent steps of business model development. Having alternative business model designs allows realizing what questions are still unanswered. Due to the active collaboration, the questions were then, answered (or processed) by other project partners. Additionally, the use of the business model tooling made the processes easier for the partners that have no expertise in business models design. In general, the existing business model tools were easy to use and to be understood. The tools were useful especially when the business team wanted to communicate them to the other partners.

Tools helped make the design process more focused, which is challenging in an opportunity creation setting. In most instances, the researchers used the tool and then presented the results to the other partners. The other participants acknowledged that the use of the tools made the process easier and more focused.

Finally, the most asked question when we were presenting new results to the project partners was what option/business model alternatives were most advisable. Deciding upon which business model or choice within a business model component is preferred (e.g., which pricing model or product offering) is a challenging task in a setting of opportunity-creation. Existing tools supported creating alternative models but did not facilitate making decisions on which alternative to choose.

5.6 Design recommendations for business model tooling

For our research, we actively intervene in an innovation project and collaborated with the project partners throughout the project while creating and revising the business models, products and enabling technologies. Tasks were divided and different teams had different tasks; however, short deliverables and frequent meetings allow teams to improve the results of their tasks fast. The realization of the start-up with initial activities and a marketable offering indicates that the project has ultimately delivered a viable business model. Our findings suggest that the use of business model tooling improves the communicability of the business model. Additionally, we observed that business model exploration is required when the value offering is not clearly defined, or when there are new business opportunities to be created.

Regarding the hypothesis, our results lead to recommendations for the development of business model exploration tools. From our research it was clear that exploration was needed thus we recommend the need for the design and development of business model tooling supporting business model exploration. Based on the observations, our recommendations regarding business model exploration are: **(a)** to start with an initial business model even if the final offering is not clear, **(b)** to create alternative business models and explore their potentials, and **(c)** use tools or practices that can contribute to the decision making on which business model alternative to pursuing (Table 5.4).

In our study, we used and tested in practice existing business model tools towards the exploration and design of business models in a setting where products are developed for yet non-existent markets.

We used tools to support the four processes of business model exploration. Finding appropriate tools was relatively easy and straightforward. Still, we encountered challenges related to the use of existing business models for business model exploration. For the ideate step, we used four business model tools. We used the widely used business model canvas tool to create a first overview of the business model of the start-up, the Persona tool to identify potential stakeholders and the STOF business model to collect ideas of project participants. While the business model canvas tool is user friendly, it was difficult to fill out the empty template as the offering was not yet defined. We had to create alternative versions of the business models, with different versions of the offerings, revenue models and involved stakeholders. We ended up with five different initial versions of the business models, all illustrated with different business model canvas versions. Regarding the STOF business model tool, it was not directly usable, as the level of detail of the checklist of questions in the tool requires a solid understanding of the offering and the stakeholders involved. We, therefore, used a simplified version of the tool, asking four basic questions related to each of the four STOF domains (service, technology, organization, and finance) in a workshop setting. During the workshop project partners proposed different alternatives for each domain (on average 4-5 different suggestions per domain). The brainstorming session showed the need for tools that do not except clear and specific answers regarding the business model components. The use of the Persona tool helped to identify potential stakeholders, even unexpected ones. For instance, in our case the involvement of local businesses that are not related to the driving situation, but do attract young people. For the reframe step we used the

Competitors analysis and Thinking hat tools to understand the current situation of the market and the competitors' analysis. These tools supported our activities and we identified potential competitors (e.g., governmental initiatives, commercial products of international companies, add-on products). Knowing the unique characteristics of the competing offerings allowed us and the project partners to focus on the added value of the start-up's offering. We started the competitor analysis with assumptions that the competitors of the startup will also offer some form of a tool/game. We identified competitors based on what they offer, their target group, their revenue group and their strategy for differentiation. By using the tools we could identify that most off the competitors offer directly to consumers, are interested in collecting data, that insurance companies are important stakeholders, and that rewards to game users are necessary. The tools were useful for the reframe step as we again did not have a clear overview of the market and the competitors. Again, analyzing the results of the market and competitors analysis, we revised the alternative business models. For the next processes of envision and action-formulation we used tools to explore potential solutions and to design the future business models. The tools we used to explore the potential solutions allowed us to create value propositions, the features of the offerings and evaluating these with potential users. For the action-formulation process, we used business model tools like the business model roadmap and the pricing strategy cards to design a plan for the future of the start-up. Overall, we found existing business model tools mainly facilitate the creation of single business model designs, and do not support the design of alternative business models that is necessary when offerings and target market is not defined. More specifically, these tools are not tailored to illustrate alternative business models. Eventually we made and iterated multiple versions of business model canvas descriptions. The use of multiple business models canvases was not sufficient as it was difficult to compare the business model components, to discuss the business models, and to record subsequent changes. Also, during the brainstorming sessions, we had difficulties to compare the models and to keep up with partners' suggestions. Our experience indicates that future business model tools need to be more automated, allow the creation and comparison of multiple business models, without creating a large number of versions of the same business model template. Finally, our experience with the business model tools is that they support the design of a business model, but largely do not support comparing and deciding upon the most optimal business model. We suggest that future business model tools should have features that support the decision-making between business model alternatives.

At the next step of our research, we will use these three recommendations as the basis for the development of the design principles for the development of an artifact to support business model exploration. The rest of the chapter focus on design principles and framework development.

Table 5.4
Recommendations for the development of the business model exploration tool.

Gaps we identified	Recommendations for future tools (Rx))
	Future business model tooling should...
Using the existing business models we had some difficulties to create alternative business model designs because we did not know the value offering.	...support the design of business models even when the building blocks are not clearly defined (R1).
Using the existing business model tools supports the creation of single business model designs.	...creating alternative business models when new opportunities are created (R2).
Existing business models do not support decision-making features about what changes, alterations, innovation should be implemented. Some existing tool related to decision making (e.g. stress testing) are focused at businesses with defined offering and operational processes.	...have functions that support the decision-making regarding alterations on the business model (R3).

5.7 Addressing the recommendations (Rx)

From the empirical research we discussed before we conclude in three recommendations that future business model tools could address. As we mentioned in the Introduction (Chapter 1), with our research we aim to design and develop an artifact (i.e., tool) that supports business model exploration. In this section we discuss how these recommendations can be addressed, that is what functions could be used in the artifact that based on the recommendations. At Chapter 3 , we reflected on existing business model tools and their characteristics. Based on that we suggest ways that the recommendations could be implemented. We developed the design principles based on the literature review and practice '*in order to instill rigor in [design science] activities before the actual evaluation work*' [197]. We address the three recommendations with the functionalities we identified and presented in Chapter 3.

5.7.1 Addressing R1

The first recommendation is: *'Future business model tooling should support the design of business models even when the building blocks are not clearly defined'.* Commonly, existing business model tooling follows a 'fill-in-the-blank' approach where users need to add information manually, and in some cases without really knowing what type of information should be added.

A solution that could support the first recommendation is the use of pre-filed templates. As pre-filled we describe a template that already has alternative options available and the users are able to choose from. In that case, information is not created by the users, but they are 'discovered' by the users from the predefined set of potential answers. The use of business model patterns is a potential way the applying the 'pre-filled' approach. We argue that this could support users to become aware of business models. Thus, we propose that a pre-filled template could be served as a mechanism for supporting business model exploration process, and it could improve the understanding of the potential business model components (e.g. building blogs).

5.7.2 Addressing R2

The second recommendation is *'Future business model tooling should creating alternative business models when new opportunities are created'.*

Opportunities cause uncertainties regarding business models and lead to the need for alternative business mode design. The alternative business models can be identified during the intermediary phase where 'pre-stage' business model is developed [52]. Cavalcante describes the concept of the 'pre-stage' business model that is the intermediary phase prior to business model change allowing the users to develop their capability to change. In that 'pre-stage' identify opportunities and explore potential changes in their business model. Exploring the existing business model tools we could not find the concept of the 'pre-stage' business model available in the literature or in practice of the business model tooling.

For instance, a business model exploration tool could support the users to identify the opportunities that IoT can add to their existing business (or business idea) and thus, to enter the pre-stage of their potential business model. A way to do this could be with the use of business model patterns. Patterns can describe proven solutions for specific domains. Thus, we propose the use of domains specific business model patterns that could support the creation of alternative business models. We will do so by focusing on the Internet of Things as the opportunity.

5.7.3 Addressing R3

The third recommendation is that *'Future business model tooling should have functions that support the decision-making regarding alterations on the business model'*. When enterprises are coming up with an idea (i.e., a change on the existing business model), the next step is to validate whether it can really deliver a compelling result and if the particular move worthwhile [161]. To do so we argue that there is a need for an assessment approach that supports the users to evaluate the changes of their pre-stage business model. We describe as assessment features the set of specific questions that the users can answer for every specific change they identified in the pre-stage. While at the literature we can find studies focusing on the evaluation of business model existing business model tools do not have features that support evaluation of business model changes and alternatives business models. We argue that evaluation can be used as a mechanism to support enterprises with their business model innovation process, adaptation and of their existing business model, adoption of business model, level of awareness and levels of confidence on doing business model innovation. Thus, we propose that the business model exploration tooling could have some assessment features such as questions or metrics in order to support users' decision making regarding changes in the business models.

5.8 Formulating the research model

The literature review allowed us to identify the kernel theories for our study that then lead to the requirements and assumptions discussed previously. As we mentioned in the previous step, we 'translated' these requirements to tool functionalities, these functionalities serve as the independent variables that we observe their influence on depended variables.

5.8.1 Independent variables

The three independent variables are

- a pre-filled pattern based business model template (IV1),
- a pre-stage business model template (IV2), and
- an evaluation schema for potential changes in the business model (IV3).

5.8.2 Dependent variables

With the business model tooling we aim to support enterprises with their business model innovation process. More specific we want to support them with the exploration of potential changes in their business model after a technology disruption. What we want to measure is if the functionalities of this tool contribute to the three depended variables

- User's understanding of the components of the current business model (DV1),
- Idea-generation on how to change different components of the current business model (DV2),
- User's decision making about whether to adopt components in the business model (DV3).

5.8.3 Research Model

Evaluation model allows us to formulate relationships, assumed by the researchers, between core concepts for a specific study [222]. We created the evaluation model (see Figure 5.5) based on the theories discussed in the previous chapters. The requirements and assumptions allowed us to create a set of functions and features that the IoT Business Model tooling needs to have. Based on Niehaves and Ortbach [174] we created the final evaluation model that includes the kernel theory constructs, the relationship between the constructs (i.e., ideas or theories that include various conceptual elements), the directly measurable variables, the potential design items (design model) and the measurement model [174].

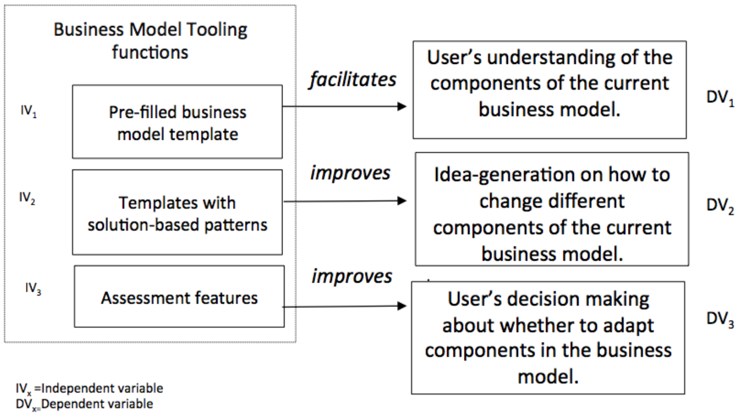

Figure 5.5
Research Model.

The utility of a DSR artifact can be evaluated and perceived through design principles [194]. With this study, we want to investigate if a unique artifact with the overall aim to support the users to explore the opportunities and the potential changes in their existing business model can improve the business model exploration process and potentially lead to business model innovation. In other words, the role of artifact should be to facilitate business model change (e.g. [156]).

Therefore, based on the research model we formulate the following Design Principles (DPx):

- **DP1**: *Pre-filled business model templates, facilitate the users' understanding of the components of the current business model.*

- **DP2**: *Templates with solution-based patterns, improve idea generation on how to change different components of the current business model.*

- **DP3**: *Assessment features, improve users' decision making about whether to adapt components in the business model.*

These design principles will serve as the basis for the development of the artifact. In the final steps of the DSR these design principles will be evaluated (i.e., the independent variables will be manipulated) and conclusions will be made whether this design alternative is preferred or not [132].

5.9 Chapter Conclusions

The aim of this chapter was to answer the second and third research questions. We collect data via action research where we actively intervene by introducing existing business model tools during an exploration process. The result of our empirical results were derived by the obstacles encountered during the process (e.g., the offering not well defined, not a clear view on who are the potential paying customers who were willing to invest in the offering, the project partners asking some examples or possible solutions for inspiration, the need for revisions and evaluation while designing the offering, decision making). Based on the results we made three recommendations regarding business model exploration that is: (a) to start with an initial business model even if the final offering is not clear, (b) to create alternative business models and explore their potentials, and (c) use tools or practices that can contribute on the decision making regarding business model exploration.

We continue by creating a research model that supports the recommendations. The research model was made based on the literature review on the existing business model tooling and their characteristics. Then, we conclude by translating the evaluation model into a set of design principles. The main interest of our research is to evaluate what features a business model tooling can have to support business model exploration process. While a business model tooling can be designed based on various features for different purposes, we focus on these three design principles, as we identify them from the action research.

A limitation of empirical research is therefore that the results are based on one single project. While the results were grounded in entries systematically collected in a logbook, the memos, minutes and emails, the active and personal involvement of the authors in this action research could be a source of bias. To increase the validity of our results we communicated to and received feedback from the project partners after each activity (e.g., by giving presentations, virtual meetings, face-to-face meetings). Another limitation of our study is the focus on the mobility ecosystem domain. While this domain is appropriate due to its rapid technology disruptions, the newcomers, the number of start-ups, and the various business models, future studies in other domains could be done to strengthen the generalizability, and the applicability of our results to other domains.

Chapter 6

Development [1]

[1]Parts of this chapter are based on: Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) Tool for Internet-of-Things business model exploration: A Design Science Research Approach In ECIS 2018, Portsmouth, UK.,
and Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) Designing digital tooling for business model exploration for the Internet-of-Things. In Desrist 2018, Chanai, India.

6.1 Chapter Introduction

This chapter discusses the design and development of the prototype of the Internet of Things (IoT) business model tooling. In it, we address the fourth research sub-question: *What functionalities can support business model exploration?* (RQ4). We start by describing the research approach we used to develop the prototype. We continue by describing the objectives that the business model tooling aims to achieve. Furthermore, the selected functions are discussed. We continue by presenting the prototype of the business model tooling and then the prototype testing. In the last part of the chapter, we discuss the iterations that took place during the prototype process, the challenges and limitations of the developed prototype, and the procedure. We conclude by providing answers to the fourth research question. Figure 6.1 illustrates the research outline for this chapter.

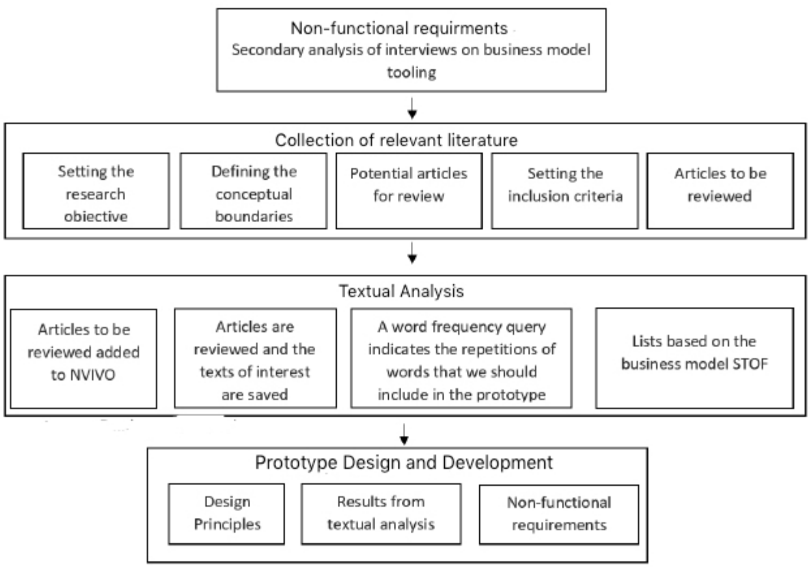

Figure 6.1
Research outline of the chapter.

6.2 Translating the design principles for the business model tooling

In chapter 5, we developed three design principles to be translated into a prototype for the business model exploration tooling. To be able to evaluate the design principles individually, we decided to follow a step-by-step approach for the development of the tooling whereby each step corresponds to one design principle. Therefore, the tooling has three steps. This step-by-step approach allowed us to create a business model tooling that we could use in the next part of our research to evaluate the effectiveness of the design principles individually, and that can be used and evaluated for its effectiveness. Because we wanted to create a business model exploration tooling, taking into consideration all the components that might change and therefore need exploration, we adopted the STOF ontology, which argues that business models can be broken down into four domains (service, technology, organization, finance) [39]. Table 6.1 shows how the three design principles were translated into a step of the prototype, and form the functional requirements of the artifact that is '*the functions that the artifact, should fulfill or enable to perform once it is realized, given the goal(s)*' [223] p.735).

6.3 Non-functional requirements

Besides, to the functional requirements, we needed to identify a set of requirements '*to be fulfilled in the process of designing regarding the interface between the artifact to be designed and the 'world outside*'' ([223], p. 735). We refer to these requirements as non-functional requirements. Non-functional requirements should be addressed as early as possible when developing an artifact [173].

Table 6.1

The translation of the three design principles to the business model tooling.

Design Principle	**Name of the step**	**Overview of the prototype**
Pre-filled business model templates, facilitate the users' understanding of the components of the current business model.	**Current business model**	-Predefined options for the service domain of the current business model -Predefined options for the technology domain of the current business model -Predefined options for the Organization domain of the current business model -Predefined options for the finance domain of the current business model
Templates with solution-based patterns, improve idea-generation on how to change different components of the current business model.	**Explore the domain**	-Explore changes in the service domain due to the IoT (from predefined lists of options) -Explore changes in the technology domain due to the IoT (from predefined lists of options) - Explore changes in the organization domain due to the IoT (from predefined lists of options) -Explore changes in the finance domain due to the IoT (from predefined lists of options)
Assessment features, improve users' decision making about whether to adapt components in the business model.	**Assess (the changes)**	-Assessment criteria for the evaluation of the previously identified (the criteria to be identified from the relevant literature)

To identify the non-functional requirements, we performed a secondary analysis of the nine interviews conducted as part of the ENviSION project was held. We chose this project because this research was performed as a part of this project, we had easy access the collected data, and one of the deliverables of the project was to create business model tooling. These interviews were conducted following a structured interview protocol developed for the specific project. These interviews aim was to identify a set of requirements and assumptions for the development of the business model tools that are available at the Business Makeover platform (`www.businessmakeover.eu`) a platform to support small and medium enterprises (SME's) with business model innovation. The description of the interviewees and the findings of this study are presented in [67].We analyzed nine interviews with business owners and supporters of businesses [67]. referred as SME's helpers) who are '*[. . .] persons that help, guide, coach or support SME's with any form of business model innovation*' (text extracted from an unofficial, internal document).

We collected the interviews and coded the text based on similar non-functional requirements that were discussed during the interviews We processed the nine interviews one by one and identified the requirements. After all the interviews had been processed, we grouped the requirements based on their similarities. We gave a descriptive code name to each of the non-functional requirements discussed. The codes were converted into short statements. Some of the requirements that were collected were functional and therefore not included in our analysis. Non-functional requirements that were discussed by only one informant were excluded. We ended up with four non-functional requirements.

The requirements extracted by the secondary analysis of the interviews were then analyzed to reach a consensus on a list of the non-functional requirements for the development of the artifact. To conclude on the functional requirements, we reviewed one by one of the recommendations from the secondary analysis. This review leads to a priority list of the non-functional requirements to be adopted. We had two inclusion points criteria for a requirement to be adopted as a non-functional requirement:

- At least two informants had to indicate the same requirement;
- Implementation of the requirement would not require financial investment;

Based on these criteria, two requirements were not further analyzed as they were mentioned by only one informant (intriguing and offline opportunities). The rest of the requirements were adopted and implemented during the development of the non-functional requirements. The requirements were implemented in different phases of the development and with different activities. Some requirements were turned into non-functional requirements related to the three design principles. The requirement related to learning was not implemented as a non-functional requirement, but we will evaluate whether and, if so, how the developed prototype facilitates learning. Other requirements were related to improving the user–machine interface—such as the requirement that the tool should be simple and have a good layout—and these requirements were implementable as they did not have financial costs attached, and their implementation was feasible. The full list of how the requirements were converted into non-functional requirements is presented in Table 6.2.

The next step was the development of a user-friendly interface. The user interface is used for the convenient communication of the end-users with the system. While the user interface design requires effort [127] it is necessary for two reasons. First, it can communicate the design principles more efficiently and thus, increase the validity of the evaluation of the design principles, minimizing potential confounders, and second, the user interface allows the implementation of the non-functional requirements. To do so we needed to create a working prototype that would allow the users to navigate through it and use it in a realistic setting to accomplish the goals of the artifact. Therefore, additional research was needed to create a more detailed working prototype. However, at this point, we had not identified these details. To do so, we reviewed the literature to identify the details that can support the transformation of the overview of the prototype into a working prototype (based on the overview and the non-functional requirements). The rest of this chapter describes the literature review and the final working prototype.

6.4 Pre-fill options

6.4.1 Literature review approach

Although the related literature on business models and business model tooling is extensive, most of it focuses more on discussing the topic at a

Table 6.2
Non-functional requirements and how we will implement them during the development of the business model tooling.

Code	Non-Functional Requirements	How the requirements were implemented at the prototype
Step by step approach	The tool should follow a step by step approach	The prototype was divided into three parts, in a sequential order corresponding to the three design principles.
Easiness	tool should be easy to follow (low entry barriers)	The prototype was designed in a way that specific training for using it or the support by an expert is not required. The prototype was designed simply way, making good use of Microsoft Excel. Programming knowledge or training is not required. Simple functions such as dropdown menus and checkboxes were added for the convenience of the users.
Results-focused	The tool should be results-focused	Each of the three steps is geared to a specific result generated by the users.
Fast	The tool should not be time consuming	Measuring the time user spends with the artifact, the maximum time of use was 2 hours.

high level of abstraction (usually in the form of what a business model is and what the building blocks are), and less on the details concerning how these building blocks can be fulfilled. For our study, we were interested in these details. These details were to be the pre-filled options of the artifact that will allow us to develop and later evaluate the business model tooling. Therefore, we continued with a literature review as our research approach.

The literature review produced the justificatory knowledge for the design choices of the business model tooling that was intended to contribute to the literature. Vom Brocke et al. [225] propose a five-step framework for conducting an information systems literature review. First, the aim of the review is defined. Second, working definitions for a common understanding of the terms used are defined. Next, the literature search process (i.e., sources, keywords, etc.) is described and conducted. Finally, the findings are analyzed and presented, see Figure 6.2.

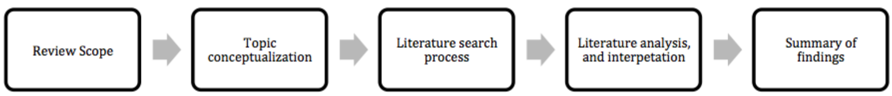

Figure 6.2
Literature review framework as suggested by vom Brocke et al. [225].

The rest of this chapter is structured based on the vom Brocke et al. [225] framework. In the following, we discuss the inputs of the literature review approach, that is, the boundaries we set, to describe the key concepts, the databases used, and the keywords. The next phase is the processing, as it can improve the quality of the literature review. The final phase is dedicated to the literature review conclusions, where the results of the analysis are explained and presented. To analyze the literature to achieve that level of detail, we performed a textual analysis.

6.5 Aim of the Review Scope

The aim was to review literature related to the three design principles (presented at Chapter 5) that would allow us to develop a working prototype based on these design principles.

Regarding the first design principle, we aimed to collect literature on what a business model is composed of at a deeper level than the building blocks. More specifically, we wanted to create a list of options for each of the literature-based business model building blocks, such as the possible options under the revenue model or the channels. For the development of the first design principle, we collected literature on business models in general.

Regarding the second design principle, we aimed to collect literature on what an IoT business model can include. We did so by reviewing the literature on the IoT business model and identifying patterns in these studies regarding what IoT business models can include. For the development of the second design principle, we collected specific literature regarding business models for the IoT.

Finally, regarding the third design principles, we aimed to review the literature on the assessment of business models and identify the factors that can allow people to assess business models. For the development of the third design principle, we reviewed the literature related to business model decision criteria.

By defining our aims, we understood that we needed to conduct three literature reviews with different keywords for the development of each design principle.

6.5.1 Topic conceptualization

The next step of the literature review framework is the topic conceptualization. In Chapter 3 we provided definitions regarding the business model and business model exploration, and we presented different business model frameworks. In Chapter 4 we discussed the IoT domain and its effect on business models.

The term we needed to clarify is "business model elements." In general, an element is defined as the *'part or feature of a whole system, plan, piece of work [...] especially one that is basic or important'*. Regarding business models, elements characterize the detailed parts of the business model components. These parts have a '*low enough level of detail to provide a level of granularity that brings ready understanding to the business model based on the collective elements without an overwhelming amount of detail.*' [3]. For instance, the building block channel can be decomposed in different elements. Szopinski et al., focusing on the Business Model Canvas, write that Business model Canvas consists of nine components, whose elements describe a specific business model [208]. For instance, the element '*Car insurance companies*' for the component

'*Customer Segments*'. See Figure 6.3 for examples of components and elements on the business model designed for the action research case presented in Chapter 5.

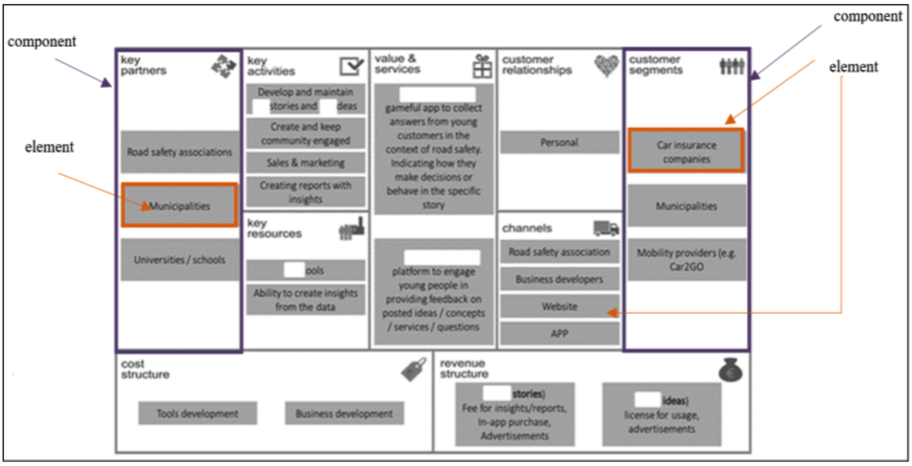

Figure 6.3
An example of the component and element of a business model (Business Model Canvas is used as an example).

In other words, we define a business model element as the options described under the business model building blocks, namely components.

In the following subsections, we present and discuss our approach to the identification of the elements that could be used to support the previously identified design principles. These elements would support the development of the business model artifact.

6.5.2 Literature review process

We searched electronic databases for papers, with appropriate selection criteria, different for each design principle. When possible, we used keywords for each level for publications from 2010 until the day of the search (the day of the research was different for each design principle). We collected publications from four electronic databases (i.e., Science Direct, Scopus, Google, and Google Scholar). The inclusion criteria for the publications were that they should be English full-text reviewed papers, journal articles, or articles in the press. To minimize the search results, and given that we were only interest in IoT about business, we restricted our search to publications related to business management, social sciences, arts, and humanities, as well as multidisciplinary areas.

In this first search round, the results were filtered to exclude purely technical articles and duplicate articles (located in different databases). See Table 6.3 for the online databases and the keywords used. Figure 6.4 presents an overview of the literature review process.

In total, we selected 162 articles.

Table 6.3
The keywords used, and the search days we extracted papers for the literature review of each level of the artifact.

DPx	Keywords search	Search day
DP1	"business model elements" OR "business model components" OR "business model patterns"	28.05.2018
DP2	("Internet of Things" AND "business model" OR "IoT" AND "business model")	20.05.2018
DP3	("assessment" AND "business model") OR ("metrics" AND "business model") OR ("evaluation" AND "business model") OR ("validation" AND "business model") OR ("measurement" AND "business model")	04.06.2018

6.6 Textual analysis

6.6.1 Why textual Analysis?

The next step of our approach was to extract 'meaning' from the collected literature. In our case, the 'meaning' we wanted to extract was the relationship between business model concepts and the three design principles. Textual analysis (or content analysis) is the research approach for studying any type of documents to extract patterns in a systematic manner [47], to enable researchers to describe and interpret the characteristics. In other words, textual analysis is '*a way of gathering and analyzing information in academic research*' [163]. When researchers use textual analysis, they can give interpretation sand potential solu-

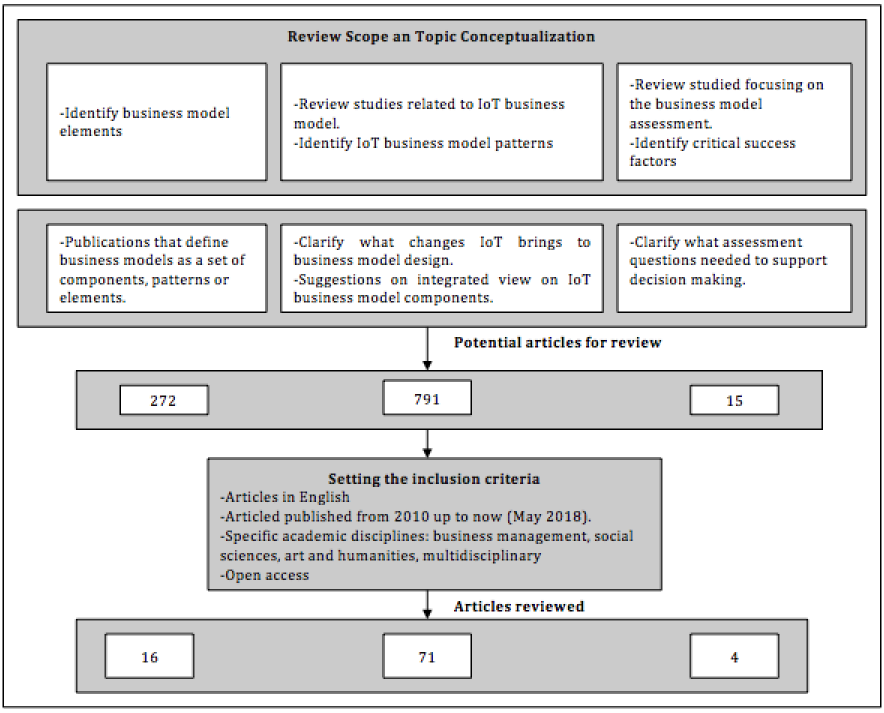

Figure 6.4
Methodology for the selection of the papers for the literature review.

tions related to a specific problem (or hypotheses) from non-numerical data [163]. A challenging aspect of the textual analysis is that different interpretations of the same text can be made [171]. While textual analysis is used for the interpretation of meanings, some errors should be avoided so given an interpretation of the researcher can be considered valid. Common errors are the inclusion of irrelevant text or ideas, the insertion of the researcher's own opinions, and the omission of key relevant information from the texts. By avoiding these errors, a textual analysis was a suitable research method for our research, as we aimed to interpret a large set of text to identify related business models and elements. Next, we discuss how we used textual analysis as our approach. For the textual analysis, we used the NVivo program [8] to store, arrange and examine the 'unstructured' data.

6.6.2 Literature analysis and interpretation

We repeated the following process three times, one for each of the design principles. We used the NVivo (version: NVivo 12 for Mac) program to store the publications and do the review of the literature. To get a first overview of the potential elements that can be included. To collect a list of the most frequently used words from the collected and analyzed texts (i.e., only the sections related to the results of each publication), we measured the word frequencies by running the relevant query in NVivo. We ran the frequency query with grouping the words based on their similarity (technology, technological, technologies). Connecting worlds such as and, thus, however, etc.) were added to the stop words list and these words were automatically excluded. We then, again ran the word frequency query, collecting the words that are referred to at least twice. Next, we used one more feature of the NVivo program, that is, the word tree feature. Word trees allowed us to identify common phrases within the analyzed text that we were not able to identify via the word frequency query. Figure 6.5 presents an example of the generated trees for the word 'networking'.

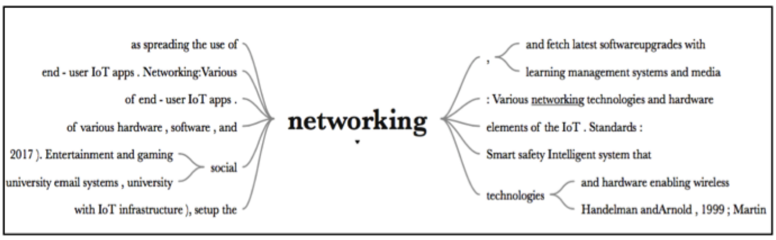

Figure 6.5
An example of the word tree feature: the word tree for 'networking' from the publications for the first design principle (NVivo).

To continue our analysis, we create a code system based on four domains of business models (service, technology, organization, and finance) [39]. The specific ontology is supported by a set of specific questions. Based on these questions, we coded specific entities about which we wanted to know what the reviewed publications say. To increase our understanding and the validity of our results, we ran a text query for each of the codes separately. We ran generic queries for the service, technology, organization, and finance domains. The results (i.e., word trees and references) were stored in the NVivo program for future reference. If the results were not clear, we searched the relevant publications. When the meaning of an element was not clear, we searched the publication from which it was extracted to understand the meaning. Table 6.4 presents the coding we developed and used for the literature review interpretation. Running the queries, we validated that all four domains are discussed in the collected literature with service to be discussed the most while organization the least. Technology and finance were discussed equally as much, but less than service.

6.6.3 Classification of the elements for the design principles

As mentioned, we collected different literature based on design principles. Therefore, we ran each of the 17 queries three times each time for different sets of literature. Regarding the first design principle we ran the queries for the relevant collected literature, aiming to identify the repetitive elements within the business model literature. Figure 6.6 illustrates the results of the query analysis of the collected literature for the first design principle.

Similar to the analysis for the design principle 1, regarding the design principle two, we focused on the literature of IoT business models, and on it, we followed the approach described above. From the analysis we realized that when focusing on IoT business models, the set of elements includes some new elements but also keeps some 'traditional' business models too. Figure 6.7 presents the final grouping of the elements related to the second design principle.

The third design principle focuses on the decision-making on which changes of newly identified alternatives in business models. The understanding of evaluation of business models affected by the technology is limited [211]. It is argued that when a business model is redesigned the use of metrics is relevant for the estimation of the feasibility and viability of the newly created business model [118]. When specifically, focusing on digitalization and the IoT, business model evaluation is mainly based on vague assumptions about the reliability of the business model. Thus, evaluating business models within the digitalization is challenging. Scholars suggest different ways to test or evaluate business models [161] [209], [57], [170], [117]). Similarly, any assumptions regarding the IoT needs some form of evaluation [33]. However, we identify a limited number of publications focusing on business model evaluation methods.

Table 6.4

The coding used for the literature analysis and the relative queries run based on the STOF ontology.

	STOF supporting question	Code(s) for nodes in Nvivo	Text query
Service	Who is the customer? Who will pay for the service?	Paying customer; Service	paying AND customer AND service
	Who is the end-user? Who will be using the service?	End-user; Service	((end-user) AND service) OR (user) AND (service)
	In what specific situation(s) would people want to buy or use the service (use cases)?	Situation of use; Use; Buy; Service	Situation AND use AND when AND Service
	What does the service do for the customer or end-user? What are the unique and distinguishing benefits of the service?	Unique characteristics; Distinguishing benefits; Product; Service	(Unique AND Service) OR (characteristic AND Service) OR (Distinguishing AND benefits)
	What is the actual offering provided to the customer or end-user? What are the distinguishable elements of the service?	Offering; Customer; End user; Product Offering; Service	(Offering AND Customer) OR (Offering AND user) OR (Product AND Customer) OR (Product AND user)
Technology	What (business) functions does the service require?	Business Functions; Business; required; requirements; Technology	(Business Functions AND Technology) OR (requirements AND Technology) OR needs
	What is the global architecture of the service offering?	Architecture; IT architecture; Information Technology architecture; Technology	Architecture OR (IT AND architecture) OR (Information AND Technology architecture) OR IT
	What user applications should be running on the technological system (e.g. for communication, interaction, content distribution, transactions)?	User application; apps; app; Communication; Interaction; content Distribution; Transactions; Technological systems; Technology	(User AND application) OR apps OR app OR (User AND app) OR Communication OR Interaction OR (content AND technology) OR Distribution OR Transactions OR (Technological AND systems)
	How are customer profiles and privacy managed?	Security; Privacy; Customer Profile; Technology	Security OR Privacy OR (customer AND Profile)
	How is secure access to, and use of, services arranged?	Secured access; Access; Usage; Use; Security; Technology	(Secured AND access) OR Access OR Usage OR Use OR
Organization	Which business roles are required to create and deliver the service?	Business roles; Internal; External; Creation; Delivery; Service Delivery; Service Creation; Organization	(Business AND roles) OR (Internal AND Organization) OR (External AND Organization) OR Creation OR Delivery OR (Service AND Delivery) OR (Service AND Creation)
	Which actors can and want to cooperate and take up the business roles?	Actors; Actors cooperation; Actors involved; Business roles; Network; Collaborators; Participants; Organization	Actors OR (Actors AND cooperation) OR (Actors AND involved) OR (Business AND roles) OR Network OR Collaborators OR Participants
	What are capabilities and resources that these actors can or should provide?	Capabilities; Resources; Actors; Internal; External; Provide; Organization	(Capabilities AND Resources) OR (Capabilities AND Resources) OR Provide
	Which resources and capabilities are critical? Hence which actors are preferable?	Resources and capabilities; Organization	Resources OR capabilities OR (Organization AND Resources) OR (capabilities AND Resources) OR (capabilities AND Organization)
Finance	What is the cost structure of the service? Investment costs, fixed costs and variable costs?	Costs; Cost structure; Investment costs; Fixed costs; Variable costs; Finance	Costs OR (Cost AND structure) OR (Investment AND costs) OR (Fixed AND costs) (Variable AND costs)
	Revenues - What is the revenue model behind the service or product? Direct payments: one-off sale, subscriptions, licenses, pay-by-tweet, indirect payments: advertising, sponsoring, subsidies, commissions,	Revenue; Revenue model; Service; Product; Direct payments; Indirect payments: Advertising; Sponsoring, subsidies; Commissions; Finance	Revenue OR (Revenue AND model) OR (Direct AND payments) OR (indirect AND payments) OR Advertising OR Sponsoring OR Commissions
	Financial arrangements - How are investments, costs and revenues divided over the actors?	Financial arrangements; Investments; Costs; Revenues; Actors; Finance	(Financial AND arrangements) OR Investments OR Costs OR Revenues OR (Actors AND Finance)

Service Domain

Accommodation	Initiative	Physical Landlord
Acquisition	Insurance brokerage	Physical Products
Experience	Information sharing	Renewable
Allowing something Different	Intangible assets	Physical Assets
Alternative way of Doing something	Integration of Third Party services	Problem Finding
Amusement	Intellectual property	Problem Solving
Association brand	Knowledge	Process
Bricks (&Clicks)	Leveraging customer	Product
Combination	Data	Quality
Construction	Logic	Quickly
Consulting	Mobility utility	Reverse innovation
Consumables	Monetization	Rewarding
Convenience	On Demand	Self-service
Copycat	Personal customer Care	Sensitive Customers Service
Customer problem	Flexibility Goods	Stationary Services
	P2P Sharing	
Customer segment	Guarantee delivery	Support
New customers	Human assets	Guidance
Customer behavior	New Products	Behavioral Change
Competitive pricing	Customer Analytics	Tailoring
Bundle of goods	Guaranteed	High Value tangible asset
Customization	Availability	Time
Data (as Service)	Shopping experience	Traditionally
Different markets	Human services	Unique products
Education	Individualization	Pay to use
Energy	Information	Learn
Enjoyment	Row	Scalability
Related services	Reduced tax	User satisfaction
Versioning	Fast delivery times	Standalone solutions
Low Cost	Reducing footprint	Separate products
Intermodal transport	Quantity	One Time Product
Low Price	Trust largely similar Products	Compose their own
Specific behavior	Right to Own	Reinventing
Opportunity	Access	Branded
Competitive package	Distinction	Personal product
Specific Target group		

Technology Domain

Analytics	Condition monitoring systems	Distribution
Assembles	Connectivity	Collaboration platform
Automated systems	Data mining	Devices
Based on benefits	Database	Aggregate data
Capabilities	Design	Embodying
Co-creation	Development	P2P service provision
Computers	Internet-mediated platforms	Platform
Engineering	Investors	Sensor
Gamification	IT	Smart utility
Gathered data	Localization	Social network
Hardware	Machine	Software
Helpdesk	Mail	Standards
Implementation	Smart services	Systems provisioning
Internet	Valuable features	Video
Innovation	Hubs	Webshop
Installation	Matchmaking	Websites
Interconnection	Online reseller	Open Source
Interface	Compatible interface	Wearables
Human services		

Organization Domain

Attractor	Costly	Exchange	Content curation
B2B	Creation	Expertise	Broadcasting
Brand Manager	Broker	Business Alliance	Management
Chains	Collective revenue	Communication	Employees logistics
Compensation	Competitors	Consultants	Employees logistics
Contactor	Contributions	Cooperation	Coordinating
Copyrights	Core	Competencies	Production
Vendor	Individuals	Trademarks	Suppliers
Outsources	Online and Physical channels	Solution Provider	Crossing
Customer Loyalty	Customer Value	Data analytics	Decentralized
Delivery dependencies	Designer	Development	Coordinating
Provider	Discount	Donors	Specialists
Employers	Wholesale	Trade fair	Manufacturing
Outsources	Supplier	Strategic Resources	Market leader
Fixed Assets	Forecasting	Fractional Ownership	Omni Channel
Government	HR	Hosting	Buy
Integrator	Independent groups of Customers	Intermediate parties	Community
Policies	Transparency	Sourcing	Consumer consumption
Optimization	Building customer base	Coordinating	Digital Service
Marketing strategy media	Maintenance costs	Production	Employees
Guided service	B2C	Suppliers	Optimization
Dimensional promotion	Proprietary	Crossing	Shop in shop
Shareholder		Coordinating	
Store/shop	Incubator	Franchiser	
	Intellectual Landlord		

Finance Domain

Add on	Indirect costs	Maintenance costs	Target the poor
Admission (rent/lease)	Branding	Marginal cost pricing	Temporary use
Advertised	Integrates	Market- oriented cost	Franchise
Affiliate programs	Additional feature	Odd pricing	Greatly
Authorizing	Not profitable	Package pricing	Group pricing
Additional cost	Adjust prices	Transaction fees	Auction
Fixed cost/rate	Dynamic pricing	Profitability	Cross pricing
Sales	Directly pricing	Purchasing	Auction
App developer	Application	Pay what you want	Financial reserves
Barter	Financial Trader	Repeated purchase	Cross selling
Behavioral segmentation	Accounting	Maintaining a profit	Price Fluctuates
Bidder	Financial trader	Cash Decoy Pricing	Freemium
Bundle pricing	Accounting	Financial landlord	Value based pricing
Cheap	Financial Trader	Actual usage	Unbundled
Commercial	Accounting	Single price	While Label
Commission	Financial assets	Penetration pricing	Premium
Complementary products	Leasing	Group Pricing	Penetration pricing low
Cost structure	Long Tail	Mass Production	Performance-based
Ultimate Luxury	Low-price	Estate brokerage	Constructing
Hidden revenue	Luxury	Sponsoring	Creaming/Skimming
Lockin	Directly traded	Subscription	Crowdsourcing
		Razors and blades	Crowdfunded
Crowd-Funded	Direct costs	Feed	Pay per use
Pay what you want	Pay for product	Two-sided (multisided	

Figure 6.6
The identified elements grouped under the four domains for the first design principle.

Service Domain			Organization Domain		
App analytics	Automated service	Co-creation service	Build	Marketplace	Customer development
Customization	Share co-creation	Self-service	Acquire and Implement	Support marketing	Development partner
Identification technology	Security service	Risk reduction	Deliver	Sales partner & vendor	Management
Sensors	Data collection	Branding	Collaborators	Processing packaging	Partner stores
Collected data	Software development	Getting the job done	Long-term customer relationship	R&D innovations	Own store
Data as service	Network	Accessibility	Software vendors	Service Delivery	Wholesaler
Virtual things	Information infrastructure	Cost reduction	Point of Sales	Intellectual property	Web sale
Actual usage	Data collection	Possibility for updates	Communities Co-creation	Human skills	Data mining distribution
Quick and efficient	Lower usage costs	Performance	Solution provider	Relations	Marketing
Customer integration	Network promotion	Comfort	Distributors	Physical resources	Design
Enabled devices	Customer directly	Convenience	Application developers and data	Functional capabilities	Manufacturers
Analyze data	Digitalization of a product	Customization	Supplier of microchips	Multiple steps: Combination	Service entertainment
Commercial service	Individualized and innovative products	Automated service	Implementation: Service production	Marketing: Sales platform	Contract manager
Device	Remote usage	Data service	Hardware makers	Software vendors	
Price	Condition Monitoring	Analyze data			
Design	Content	Newness			

Technology Domain			Finance Domain		
Information technology	RFID	Enabled platform	Buy	Installation fees	Digital add-on
Production data	Layered architecture	Hardware	Post- purchase	Subscription fee	Pay-as-you go
Use of virtual things	Embedded technology	Software	Network advertisements	Licensing	One-time fee
Online database	Wireless sensor	Platform Integration	Mass customization	Brokerage fees	Premium
Security	IP based networks	Process optimization	Cross selling	E-retail	Digital add-on
Connectivity	Service Computing	Security	Advertise	Group pricing	Freemium
Marketplace	Data storage	Implementation Platform	Sell	Creaming/ Skimming	Object self-service
Software Development	Ubiquitous wireless connectivity	Integrating physical devices	Rent/Leasing	Wholesaling	Cheap
Architecture design and develop	Wireless communication		**Usage fee**	**Brokerage fees**	**Dynamic pricing**
			Subscription	Pay for results Remote usage	Competitive pricing

Figure 6.7
The identified elements grouped under the four domains for the second design principle.

Recent publication [118] provides an overview of the evaluation criteria, and therefore we used this publication as the basis for the development of the third design principle. However, we used specific keywords to collect related literature for validity reasons. The keywords were 'business model evaluation', 'business model assessment', and 'business model metrics'. Due to the small numbers of papers when we did the textual analysis, the codes used for the previous two design principles were not used as they were too complicated. However, we used the previously described methodology as much as possible, and with the use of NVivo we grouped the similar concepts, see Figure 6.8.

Service Domain	
Development time of new service	
Quality	Sustainability
Customer relations	Targeting
Created customer value	Customer retention
Website-related indicators	Creating value element
Market segment and market share	

Technology Domain	
	Security
Architectural complicity	Data complexity
Accessibility and up-time	Quality of service
Accessibility for customers	System integration
Data security/integrity	
Interoperability	

Organization Domain	
Number of internal partners	Value exchange
Access to resources	Value attributed
Number of external partners	Value conflicts
Partner selection	Number of partners
Number of primary process	Data exchange
Process throughput	Knowledge development
Knowledge development	Process variety
Number of partners	Network openness
Information accessibility	Network governance
Characteristic of internal network (e.g. size connectivity)	Network complexity

Finance Domain	
Network value	Division of investments
Profitability	Division of costs and revenues
Costs	Pricing
Risk	

Figure 6.8
The identified elements grouped under the four domains for the third design principle. ([39], [118].

6.7 Prototyping

We created the prototype based on the three design principles, the results of the analysis and the identification of the non-functional requirements. In the following sections, we discuss and present the prototype about design principles. We then discuss how the generic list of elements was converted into a working prototype (where the non-functional requirements were taken into consideration). Below, we discuss and present the design principles one by one, and then present the final prototype of the artifact.

Reflecting on the newly created lists of elements, we assumed that this form is not user friendly. Additionally, we grouped the elements into four groups based on Bouwman et al. [39] who also mention that to use the four domains appropriately, a set of detailed questions should be made. We, therefore, decided to develop the working prototype based on detailed subsections (within the four domains). To do so, we adopted the recommendations made [190] who identified repetitive patterns within the business model literature. Their study served as a detailed basis for the working prototype, with the elements to be rearranged in one of the four detailed groups, namely:

- Offering, Strategy for differentiation (under service domain),
- Technical requirements (under technology domain),
- Resourcing, value-delivery process, value creation process, People (under organization domain),
- Revenue model, Pricing (under finance domain).

To validate the fitting of each element under a category, we used the database we created in NVivo to understand what the publications mean with the specific element.

The grouping was based on which elements correspond to the questions extracted by the taxonomy developed by Remane et al. [190], who created a taxonomy of business model patterns when reviewing the literature on business model patterns. Quoting their words, they created a taxonomy with which the '*overarching dimensions describe aspects affecting several business model components simultaneously*' [190], p. 21). Using this taxonomy for the components, allowed us to group the previously identified elements under these components.

Creating a prototype, and thus a business model tooling that corresponds to the DP1 (*using pre-filled business model templates facilitates the user's understanding of the components of the current business model*) requires a function that supports *pre-filled templates*, a function that takes into consideration the non-functional requirements, and a function that provides an overview of a business model.

We addressed this requirement with the use of drop-down lists of potential answers to specific questions addressed in the prototype. In that case, the users are not required to insert (e.g., by free text fields) a potential answer but they can choose from a list of potential answers (i.e., the elements). Having a dropdown list rather than the 'traditional' fill-in-the-blank business model tooling approach is subject to the evaluation (see chapter 7). We used the prototype to address most of the non-functional requirements. The non-functional requirements were addressed about the first design principle are:

- Te only requirement is to choose from a drop-down list and it is not time-consuming and does not require connectivity. The layout is simple and based on pre-existing business models layouts.
- The result is the outline of an existing business model (results-focused; traditional elements).
- The drop-down option addresses both alternatives and pre-filled options

Figure 6.9 presents an overview of the prototype for the first design principle.

After creating the groups, we continued with the fitting of the elements into one of the groups. As mentioned, before we added an element to one of the corresponding groups, we evaluated how the authors describe the element. We should mention that it is possible that if other researchers follow our approach they might come up with different results, as they might interpret the grouping differently way. Figure 6.10 presents the final grouping of the elements intended to support the first design principle.

Creating a prototype, and thus a business model tooling that corresponds to the to the second design principle (*Using templates with solution-based patterns improves idea-generation on how to change different components of the current business model, given a specific technology disruption*) requires: (1) A function that supports business model

Service Domain	Organization Domain
Offering: What type of offering does the enterprise provided to its customers?	**Resourcing:** How does the company create its offerings?
Strategy for differentiation: What differentiate the company from the competitors.	**Value-delivery process**: How does the company deliver your offerings to your customers
Technology Domain	**Partners:** What partners are needed?
Technical functions: What technologies are needed?	**Finance Domain**
	Revenue model: How does your company earn income and produce profits? Pricing: How do you price your products?

Figure 6.9
An overview of the components and questions included at the working prototype for the first design principle [190].

patterns, (2) taking into consideration the non-functional requirements, and (3) the outcome to be the potential changes as an effect of a technology disruption. A function that supports solution-based business model patterns: We addressed this requirement with the use of 'checkboxes', 'drop-down lists' of potential answers to specific questions addressed in the prototype. The drop-down lists the checkboxes allow multiple elements to be chosen, and allows more potential solutions to be addressed. The answers were derived from the textual analysis discussed previously.

Also, to the four domains of the prototype, the textual analysis of the IoT business models indicated the additions of one more domain, specifically related to the IoT. With the specific prototype we addressed most of the non-functional requirements. The non-functional requirements were addressed about the second design principle are:

- The only requirement is to check the boxes with potential changes from a predefined set of checkboxes; some text input is required
- The result is a set of potential changes that can be implemented

Offering: What type of offering does the enterprise provided to its customers?		
Accommodation	Information	Stand-alone products
Customer behavior	Monetization Physical assets	Right to own
Acquisition	Initiative	New products
Adapted Customer experience	Initiative	One tome product
Combination	Intangible assets	Physical landlord
Largely similar products	Self service	Bundle of goods
Construction	Custom made	Guidance
Consulting	Reverse innovation	Knowledge
Consumables	Energy	Leveraging customer data
Customization	Data as service	Branded
Access	Logic	

Strategy for differentiation: What differentiate the company from the competitors.		
	Convenience	Renewable
Amusement	Copycat	Rewarding
	Customer problem	New customers
Alternative ways of doing something	Customer segment	Shopping experience
	Customization	Quality
Brick (& clicks)	Enjoyment	Complete package
Reducing footprint	Guarantee delivery	Scalability
Competitive pricing	Individualization	Low price
Trust	Guaranteed availability	Satisfied
Problem finding	Novel	Low cost
Reinventing footprint	Problem solving	Fast delivery

Technical functions: What technologies are needed?		
Analytics	Condition monitoring systems	Distribution
Assembles	Data mining	Collaboration platform
Automated systems	Database	Devices
Based on benefits	Design	Aggregate data
Capabilities	Wearables	Embodying
Customer analytics	Online reseller	Compatible interface
Interface	Development	Open Source
Co-creation	Internet-mediated platforms	P2P service provision
Computers	Investors	Platform
Engineering	IT	Sensor
Gamification	Localization	Smart utility
Gathered data	Machine	Social network
Hardware	Mail	Software
Helpdesk	Smart services	Standards
Implementation	Valuable features	Systems provisioning
Internet	Hubs	Video
Innovation	Matchmaking	Webshop
Installation	Communication networks	Websites
Interconnection	(Big) data	Mobile technology
Sensor technology	API (Application programming interface)	Social network
Wearables		

Resourcing: How does the company create its offerings?	
Buy from other companies	Make everything ourselves (Insourcing)
Human Skills/Expertise (Skilled/ qualified employees)	

Value-delivery process: How does the company deliver its offerings to the customers?	
Via third parties (reseller/retailers)'	Delivered by People
Physical store	

Partners: What is the kind of partner that the company cannot operate without? (employees are excluded)	
Service Provider	Insurer
Digital Service Provider	Logistics expert
App developer	Technology Consultant
Hardware Provider	Finance Consultant

Revenue model: How does your company earn income and produce profits?	
Add on	Pay for Actual Usage
Rent/Lease (a product)	Commission
Advertising	Freemium
One time fee	Licensing
Affiliation	

Pricing: How do you price your products?	
Bundle Pricing (Bundle of goods or services for a lower price)	Pay Per Use
Fixed price	Value based pricing (Price depends on benefits for customers)
Dynamic Pricing (Prices remain flexible/adaptable)	Different Prices (For different customers)
Package Pricing	Market-oriented Pricing
Auction (The highest bidder gets the offering)	

Figure 6.10
Final organization of the prototype regarding the first design principle.

thought the business model innovation (results-focused; traditional elements).

- The check boxes and the open questions address both alternatives and pre-filled options.
- The prototype for the second design principle will require the outcome of the prototype for the first design principle. The artifact will 'guide' the users through every step (step by step approach).

The outcome is the potential changes resulting from technology disruption. Again, the prototype corresponding to the second design principle is based on [190]. However, for the prototype of design principle 2 some alternations were made to fit the IoT ecosystem (see Figure 6.11).

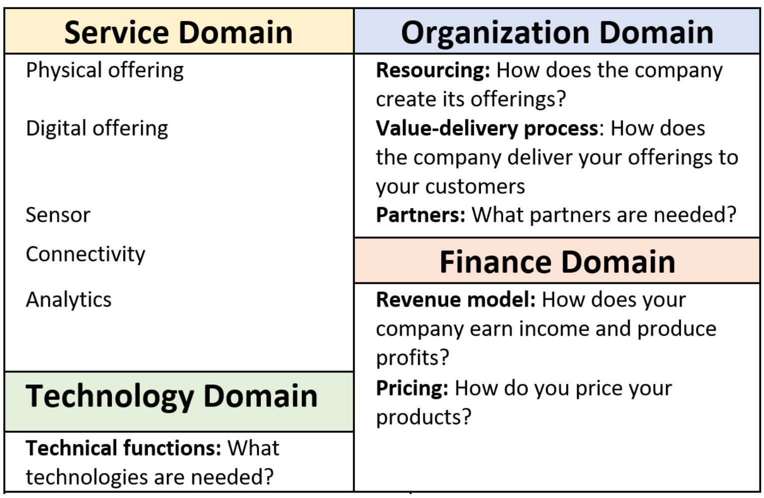

Figure 6.11
Second iteration of the prototype for the second design principle development based on Remane et al. [190].

After creating the groups we continued with the fitting of the elements in one of the components. As we mentioned before, we added an element to one the corresponding group, we evaluate how the authors describe the element. We should mention that it is possible that if other researchers follow our approach they might come up with different results as they might interpret the grouping differently. Figure 6.12 presents the final grouping of the elements aiming at supporting the second design principle.

Offering: What type of offering does the enterprise provided to its customers?			**Technical functions:** What technologies are needed?		**Resourcing:** How does the company create its offerings?		**Revenue model:** How does your company earn income and produce profits?	
Accommodation	Information	Stand-alone products	Aggregate Data	Automated Systems	Broker	Co-Creation	Digital add On	Market-oriented Pricing
Customer behavior	Monetization Physical assets	Right to own	Hardware	Software Vendors	Outsourcing	Insourcing	Admission (rent/lease)	Subscription Fee
Acquisition	Initiative	New products	Analytics	Helpdesk	Buy (from a third company)	Software development	Fixed Fee/ Rate	Fixed Cost
Adapted Customer experience	Initiative	One tome product	Interface	Marketplace	Use of a community (e.g. social media)	Human Skills	Advertisment	Pay for Actual Usage
Combination	Intangible assets	Physical landlord	Architecture Design and Develop	Sales Partner & Vendor	Expertise		Package Pricing	Maintaining a Profit
Largely similar products	Self service	Bundle of goods	Platform Development	Service Entertainment	**Value-delivery process:** How does the company deliver its offerings to the customers?		Authorizing/licensing	
Construction	Custom made	Guidance	Universal Wireless Connectivity	Mobile App	Own Store	Intermediate parties	**Pricing:** How do you price your products?	
Consulting	Reverse innovation	Knowledge	Frequency Identification (RFID)	Systems Provisioning	Websale	Human Services	Bundle Pricing	Pay to use
Consumables	Energy	Leveraging customer data	Computers	Physical Resources	Marketing Sales Platform	Delivered by People	Additional Feature	Pay-as-you-Go
Customization	Data as service	Branded	Distribution	Process Optimization	Via third parties (reseller/retailers)		Group Pricing	Pay Per Use
Access	Logic		Integration of Physical & Digital Devices		Physical store		Dynamic Pricing	Rent
Strategy for differentiation: What differentiate the company from the competitors.			Gathering of Data	Solution Provider	**Partners:** What is the kind of partner that the company cannot operate without? (employees are excluded)			
Accessibility	Quick and Efficient	Software Development	Enable Platform	Social Network	Business Alliance	Consultants		
Actual Usage	Convenience	Digitization of a Product	Associations Brand	Localization	Data Analytics Provider	Distributor		
Customization	Complete Package	Security Service	Embedded Technology	Internet-mediated Platforms	Development Partner	Manufacturers		
Analyze Data	Enabled Devices	Attractiveness	Smart Services	Database	Service Provider	Collaborators		
Sensors	App Analytics	Price			Application Developers			
Higher Performance	Alternative Way of Doing Something	Low Price						
Automated Service	Data As a Service	Collected Data						
Customer Satisfaction	Self-Service	Personalized Product						

Figure 6.12
Final organization of the prototype regarding the second design principle

We created a set of requirements for the DP3 (*Assessment features, improve users' decision making about whether to adapt components in the business model*) requires: (1) A function that supports assessment elements (2) taking into consideration the non-functional requirements, and (3) the result should be a list of short answers to specific questions related to the potential changes to the business. The following three other requirements had to be addressed during the development of the prototype. A function that supports assessment elements: We addressed this requirement with a set of questions extracted from the literature. The mean functionality of this prototype is the use of a specific dropdown list of three single-word answers (yes, no, maybe). The purpose of these dropdown lists is to get the user's intuitive answer to the questions based on the elements (i.e., potential changes to the business model). Take into consideration the non-functional requirements: With the specific prototype, we addressed most of the non-functional requirements. The non-functional requirements addressed the second design principle are:

- The only requirement is to check the boxes with potential changes from a predefined set of checkboxes, some text input is required (simplicity, easiness, fast, offline).
- The drop-down lists address both alternatives and pre-filled options (alternatives, pre-filled options).
- The prototype for the third design principle will require the outcome of the prototype for the second design principle. The artifact will 'guide' the users through every next step (step by step approach).

User's decision making: As we were interested in developing an artifact for business model exploration, we wanted to offer users the opportunity both to change and to keep elements from their existing business model. Thus, the prototype for design principle 3 allows the users to answer specific questions for the potential business model changes the user identified as possible in the previous step of the process.

At the prototype, the chosen elements, from the previous step, are presented in rows. The changes are grouped together and only the relevant metrics are presented per group of changes. To make the process user-friendly, the assessment metrics are converted into questions and a list of predefined answers is available. Finalizing this step, the users can have an overview, according to their self-evaluation, of which changes to the existing business model are more promising, and thus to make decisions toward implementing the changes. Table 6.5 presents the overview of the identified metrics and the conversion to questions that can be used for prototyping design principle 3. The evaluation metrics are extracted from a repository [117]. However, for a practical business model tooling with the non-functional requirements, we are not able to include all the metrics, as the non-functional requirements cannot be applied. Thus, we decided to only use the two most applicable evaluation metrics related to the critical success factors [39] that apply to both traditional and technology influenced business models.

Table 6.5
Business model component, explanations, critical success factors andfinal questions to be included at the prototype.

Business model component	Explanation	Critical success factors	Questions
Service	Compelling Value Proposition	The benefits that are delivered to the user of a service by its provider	Do you think that will contribute to creating value for the target users of the service?
	Defined Target group	Enables the service provider to stay focused on the customers.	Do you think that this change will reach more customers
Technology	Architectural complexity	Will the technical requirements will affect architectural complexity?	Will this change support systems integration?

Continued on the next page

Table 6.5 – continued from the previous page

Business model component	**Explanation**	**Critical success factors**	**Questions**
Organization	Sustainable Network Strategy	Securing access to inimitable resources and capabilities	Will this change require more/less internal partners?
	Acceptable Division of Roles	Distribution of roles.	Will this change affect the value exchange between partners?
Finance	Accessible Profitability	A positive financial result Profitability	Do you think that this change will lead to a positive financial result?
	Accessible Risks	Market acceptance	Do you think that this change will increase financial risks?

6.8 Overview of the developed prototype

The business model tooling was developed in Microsoft Excel (14.6.4), as it allowed us to incorporate almost all the non-functional requirements. More specifically, characteristics of Excel allowed us to follow a step-by-step approach (tabs, links) and to keep the process simple (only very basic computer use knowledge is required) and easy, as it only requires choosing from predefined options. It also allows the creation of a good layout and pre-filled options, while it does not require Internet. Regarding the layout, Excel provides many options. We decided to create a layout that resembles a webpage. We did so by introducing the link option that Excel provides (similar to the hyperlinks that allow the connection of different pages on the Internet and thus the creation of websites as we know them). The user first communicates with the business model with an Excel sheet that we call the 'homepage'. The homepage introduces the business model exploration tooling and allows navigation within the whole worksheet. From the homepage, the users get an introduction on what the tooling is about and they are encouraged to start using it for their specific case. Figure 6.13 presents the 'homepage' of the business model tooling.

The next page is based on the second design principle. For this page, we made use of various features, namely text boxes, checkboxes, and the automatic filling of cells with options from other sheets. More specifically, the results from the previous step are automatically imported for the convenience of the users, while checkboxes allow them to choose many options regarding potential changes in the business model they described previously. Focusing on the technology disruption and mainly on the IoT, the users are guided and encouraged to use the text boxes to identify a way in which the existing offering can be transformed into an IoT offering. Figures 6.15, 6.16, 6.17, 6.18 present the final prototype of this page. As in the previous page. Again links are provided that enable users to go on to the next step, save their progress, or return to the homepage, save their progress or return to the homepage.

Figure 6.13
Homepage of the ΩmeGA business model tooling.

After the homepage, the users are directed to the next page (a new tab on the same Excel Worksheet), which is designed based on the first design principle. For this page, we made use of the dropdown list function to translate the prototype of the first design principle as presented in Figure 6.14 . Additionally, we wanted to have a good layout, so we used different colors and font sizes to improve the user interface. The users can make use of the dropdown lists and create an existing (or an initial) business model for a specific case.

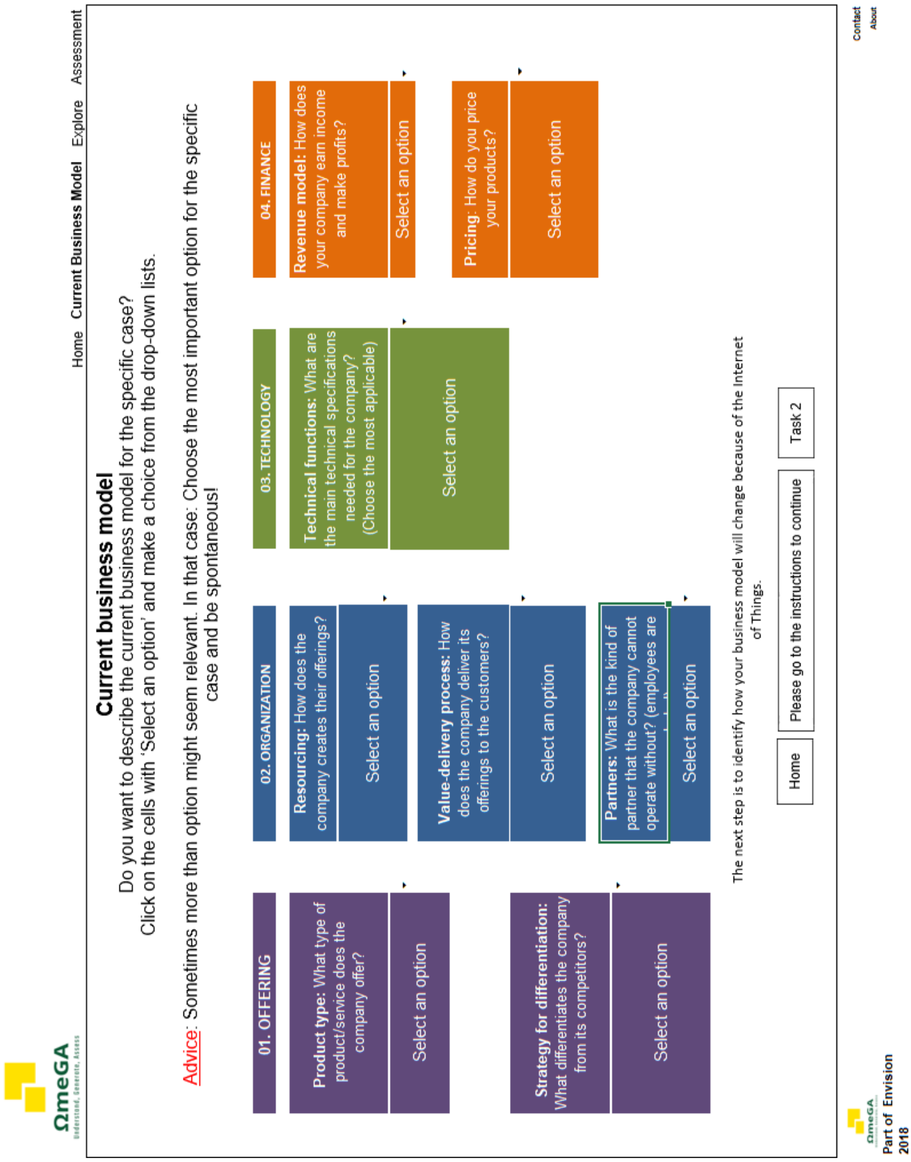

Figure 6.14
Screenshot of ΩmeGA business model tooling representing the design Principle 1.

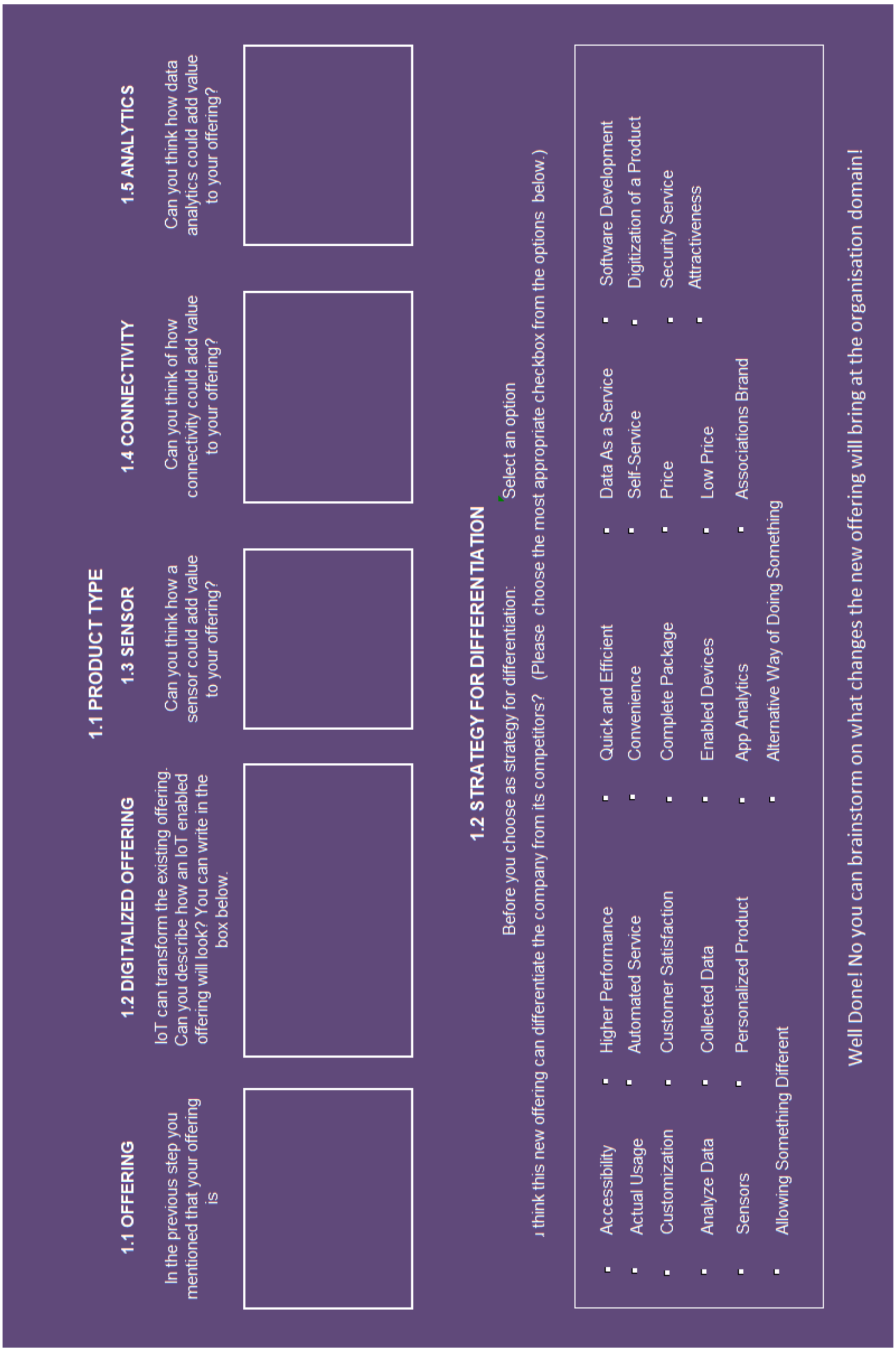

Figure 6.15

Screenshot of ΩmeGA business model too[redacted]*ting the design principle 2 (Service Domain).*

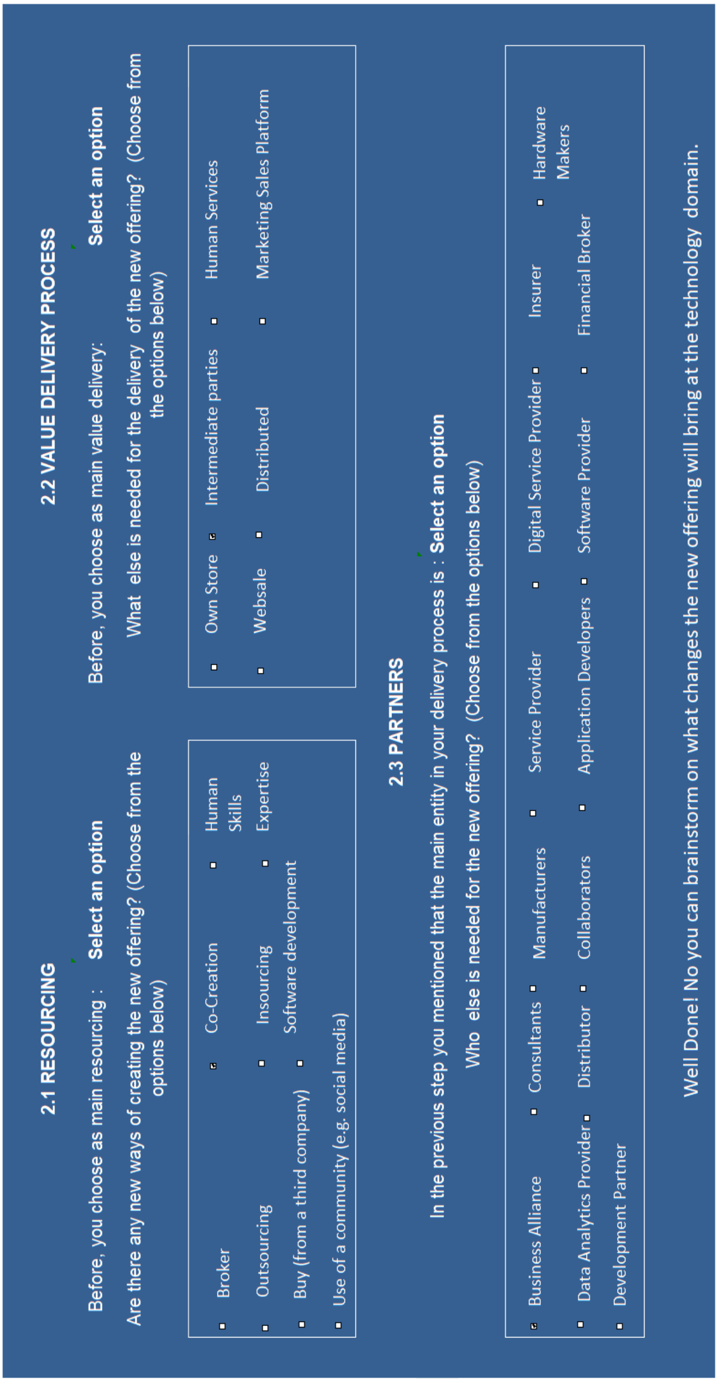

Figure 6.16
Screenshot of ΩmeGA business model tooling representing the design principle 2 (Organization domain).

Figure 6.17

Screenshot of ΩmeGA business model tooling representing the design principle 2 (Technology domain).

Figure 6.18
Screenshot of ΩmeGA business model tooling representing the design principle 2 (Finance domain).

The following page addresses the third design principle. For this page, we again made use of automatic filling, dropdown lists, and the option to color the cells based on their value. On this page, the users can review the potential changes they identified on the previous page (imported into that page automatically) based on a set of questions. The answers to the questions—Yes, No, and Maybe—are options on each dropdown list. Based on the answer chosen, the cell changes color (Yes: green; No: red; Maybe: yellow). This gives user the overview (based on their intuition) of which changes are more likely to succeed if implemented. Links to all the other pages are available once again 6.19 presents a screenshot of that sheet.

Figure 6.19
Screenshot of ΩmeGA business model tooling representing the design principle 3.

Additional elements of the prototype are: A page with additional information regarding the development of the business model tooling as part of a study, and an option for communicating to the researchers any problems or feedback concerning the Envision project, of which this study was a part. See figure 6.20 for the screenshot of this page.

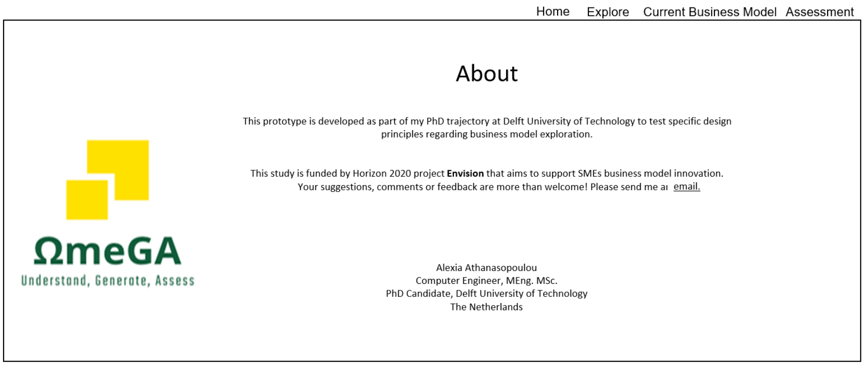

Figure 6.20
'About' page of of the ΩmeGA business model tooling.

6.9 Feedback

To improve the artifact, we collected feedback in various ways. In this section, we present the formal and informal feedback we collected when presenting the developed prototype to academics (senior and junior researchers), practitioners, and Master's students interested in business models. When possible, the feedback was implemented (before the final evaluation discussed in 7). In some cases, the feedback was well received but we did not manage to include it due to certain inevitable limitations. This feedback focused only on improving the artifact and not on the design principles discussed in 5 that contribute to the business model exploration. 7. This initial feedback allowed us to revise the artifact when possible based on recommendations from software engineers, business consultants, and potential users on how the artifact could be improved in terms of usage, user interface, functionalities, layout, and wording. In other words, this feedback exclusively focuses on the non-functional requirements of the developed artifact and how it could be improved. In this section, we discuss how we collected the feedback and the recommendations and finally which of the comments we finally implemented. Table 6.6 shows the various ways we collected the feedback.

We asked software developers to identify any major or minor technical issues. The software developers used and tested the prototype, and then completed an online questionnaire. We asked questions regarding major and minor mistakes (e.g., bugs), time estimation, and the response of the tool in different actions. The software developers identified minor problems with the usability of the artifact and automated requests. Nonetheless, they said that the artifact was relatively ready to be used.

Table 6.6
Details of the feedback collection for the prototype

Informants	**Duration and Location**	**Focus of the feedback**	**Data collection methods**
Software developers (3)	20'; Online	Technical requirements	Shot online questionnaire
Junior researchers (10)	(Time was not specified)	Informal testing of the prototype and the methodology for improvements	Written memos, Open questions
Technology and business consultants (4)	1.30'; Online (via Skype); face to face meeting	Principles, Functional and non-functional requirements	Interviews, minutes were collected
Students with entrepreneurship focus (23)	(Time was not specified)	Use of the tool in practice	Observations, Open questions

Junior researchers evaluated the non-functional requirements, by using the artifact for a specific artificial case that was given to them. The junior researchers provided their comments in a written form and they answered specific open questions. Table 6.7 presents the feedback we received and the adjustments before the creation of the clickable prototype.

Table 6.7
Comments, feedback, and errors.

Feedback	Our adjustments
Ease of completing the tasks	Detailed explanations of how the tool can be used. Example of how the tool can be used is available via online mock-up prototype.
Usefulness	We added to the introductions that the purpose of the artifact is to support and give inspiration.
Mental effort required	The comments regarding mental effort were diverse. Thus, we did not make any major changes. We worked on making the instructions and the tooling as simple as possible. The components part is one of the major functionalities that we want to test. Thus, it cannot be changed.
Experience with the artifact	Most of these comments were implemented. Also at the post-questionnaire some questions will be added regarding the experience with the artifact. The answer to these questions can test the validity of the artifact.
Complexity	Regarding the transformation, a specific case is designed to support the users and it will be given as an example. The transformation level was revised and the users are asked to think of a generic idea and then to think about details.
Time	We received different comments regarding the timing so we are not able to determine how long is enough for the use of the tooling.

Continued on the next page

Table 6.7 – continued from the previous page

Feedback	**Our adjustments**
Instructions	Example will be added. The instructions were revised and more detailed were added.
Structure	We made the structure more cleat, with more explanations and details when needed.
Layout	Recommendations concerning colors, fonts, and other issues related to the layout were immediately implemented.
Wording	Revisions were made. to understand were replaced with other words. Short explanations/definitions were added.
Understandable	Definitions were added, Extra information was added when needed.
Usability	The comments were implemented to improve usability. Unofficial recommendations concerning improvements were also made.
Generic comments	The specific comments/questions were implemented and contributed to revised descriptions and introductions.

Four technology and/or business consultants with experience of business models and technology disruption accessed the prototype before the informal meetings. During the meetings, they provided recommendations, asked clarification questions, pinpointed problems, and acknowledged the potential of the prototype. Minutes of the meetings were kept.

Finally, we asked potential users of the artifact to test it and comment on the non-functional requirements. To do so, we asked 23 Master's students with an interest in entrepreneurship to use the prototype and provide comments for a specific artificial case (the same one the junior researchers used). The participants used the prototype and provided written comments in the form of answers to open questions and a short questionnaire. Additionally, while the participants were using the prototype, observations were collected by the facilitators.

To summarize, the consultants commented extensively on the last step (assessment of the changes). They said that this step requires a lot of time and that the users might not find that appealing. Additionally, they said that we cannot use the same key performance indicators (KPI) for each potential change. Finally, three of the beta testers suggested that the tool needs to provide a final recommendation to the users in the form of a prioritization list of the order in which the identified changes should be implemented. One of the beta testers said that this would contribute more to the users' decision making because they will have some concrete actions to shortly. All the consultants said that the tool needs to be more automated (e.g., to give suggestions, to prioritize without requesting the users to do it on their own, etc.). One of the consultants pointed out that the 'open questions' answers should be eliminated because users prefer to brainstorm and decide on specific recommendations.

Layouts and color codes were well received but some improvements can be made, as the informants got confused in some situations. Two of the consultants said that the illustration of the existing business model (step 1 of the tool) should always be visible so that the users can identify potential changes to their existing business model. Some of the participants mentioned that some of the words and definitions used in the Excel sheets (i.e., the prototype) were difficult to understand.

Finally, we analyzed the facilitators' observations. From the observations, it was clear that the participants had been engaged in the process and the use of the tools. However, the observers noted that the informants had some issues with understanding the wording, that the process was time-consuming, and that the layout of the prototype could be improved.

The design and development of the artifact took approximately two years. A literature review and examples from the practice indicated the initial requirements. Throughout this period, we presented the research and the current progress to experts (academics and practitioners), who provided their opinions, new ideas, and features, which were considered until the business model tooling became more focused. This iterative process led to revised versions of the business model tooling and how it can be structured.

6.10 Chapter Concussion

This chapter addressed the fourth research question of our study. We collected literature relevant to three design principles, we collected relevant literature and then reviewed it using the NVivo program. In NVivo, we coded the relevant text to the four STOF domains (service, technology, organization, finance) and identified elements that could inform the detailed description of the business model tooling. Then a more detailed analysis informed the prototype of the business model exploration tooling. We discussed how non-functional requirements were applied. We concluded by presenting the interface of the artifact and some feedback. The artifact was well accepted, and recommendations from various informants were applied. However, the effect of the developed artifact on business model exploration is still not known.

A limitation of this study is related to the literature review process. Although we did a thorough literature review and collected a large number of publications to analyze during the network analysis, we might have overlooked some publications. Also, the results of the network analysis might be subject to another interpretation if performed by other researchers.

Chapter 7

Evaluation [1]

[1] This chapter is based on Athanasopoulou, A., De Reuver, M., Janssen M. Evaluating business model tooling functionalities. An experimental design *under preparation*, and Athanasopoulou, A., De Reuver, M., (2018) Designing business model tooling for business model exploration: An experimental design for evaluation. Proceedings of the 29th Bled eConference, Bled, Slovenia.

7.1 Chapter Introduction

In this chapter, we discuss the evaluation we performed for the last phase of our design science research (DSR). This phase contributes to answering the final sub-question, namely '*What are the effects of the developed tooling on the business model exploration process as identified in theory and practice?*'. We discuss the two evaluation cycles we performed, and provide a detailed description of the whole evaluation process and the methodology we followed. Finally, we discuss the results.

The evaluation for this research involved two phases, namely first phase evaluation and second phase evaluation. An experimental design was developed for the overall study to test how well the developed artifact offers a solution for a specific problem [184]. The first phase concerned the evaluation of the experimental design. We performed this evaluation soon after we developed the artifact and the experimental design. We collected feedback from various informants regarding improvements of the artifact's functionalities and finally drew the preliminary conclusions regarding the effect of the artifact on business model exploration. The results from the first phase allowed us to improve the experimental design. The second phase evaluation was the summative evaluation, where experiments were conducted to evaluate the effect of the artifact on business model exploration.

The chapter is structured as follows. First, we discuss the experimental approach as a research method for evaluation. We continue with the role of experimental design in DSR studies. Then we present our preparations for our evaluation, followed by the approach of the two evaluation cycles. We continue with the results. We conclude with the limitations of our experimental design and the possible improvements.

7.2 Evaluation in DSR

We wanted to evaluate the three design principles. Evaluation is considered a crucial element of the validation, revision, and control of DSR projects or products [97]. Recent literature on DSR stresses the role of evaluation ([121], [184]). Evaluation is described as 'systematic investigation of the excellence of an instrument' [32]. The primary goal of any DSR project is to develop a new artifact to resolve a previously unsolved problem while contributing to the literature [97]. Evaluation should, therefore, deliver evidence that the artifact is a satisfactory solution that fits the purpose for which it was designed, providing an efficient and improved solution ([165] [180]). In other worlds evaluation is an important step of the DSR approach because it indicates '*how well the artifact performs*' ([153], p.254).

Evaluating the utility of a DSR artifact is challenging [198]. Artifact evaluation assesses (a) whether the artifact is an '*improved solution*' and (b) if the artifact works in a real life setting [54]. Peffers et al [184] suggested two steps for DSR evaluation. The first step is a demonstration that it is feasible to implement the artifact, while the second step concerns how well the artifact works. To do so, researchers need to create an evaluation procedure that tests the developed artifact(s) for the identified problem in a realistic setting [165].

Evaluation can be performed in an external setting (i.e., outside the researchers' team), or an internal setting (i.e., within the design team) or in a mix of both, and always requires an explanation of the choices [193]. Additionally, the setting can be naturalistic or artificial [128]. A naturalistic setting is where the evaluation is conducted in a real environment (including complexities that might occur due to human complexities), whereas artificial is the setting where evaluation is conducted in a non-realistic and predefined setting [198]. In this study, we choose an artificial setting because it would give us more control over confounding factors, and thus higher internal validity. Hevner et al. [121] argue that five evaluation methods can be followed during DSR. These methods are observational (e.g., case studies), analytical (e.g., dynamic analysis, optimization), testing (e.g., functional testing), descriptive (e.g., scenarios to demonstrate its utility), and experimental (controlled experiments). We followed the last evaluation approach by conducting controlled experiments in an artificial setting.

The experimental approach has been recognized as one the most important ways to evaluate and confirm the usefulness of an artifact [97]. In chapter Chapter 5 we developed three design principles based on an assumption over the effect of an independent variable (functionalities) on a dependent variable. Additionally, experimental approach allows us to control over confounding factors that could occur when following a different evaluation approach (e.g., when analyzing observations of a case study), and at the same time increase the internal validity. Thus, experiment as a form of evaluation is suitable for our DSR research.

7.2.1 Experimental Design in DSR

An experiment is described as an intervention that the researchers deliberately introduce and then observe its effects on a specific setting ([85], [196], [77]). Experiments are used to support (or reject) a theory that explains real-world phenomena. Researchers conduct experiments in a laboratory setting to observe the effects of independent variables (cause) on dependent variables (effect) [77]. Experiments facilitate this causal relationship by following the principles of (a) control, (b) randomization, and (c) manipulation [176]. To apply these principles, the participants in experiments are asked to perform specific, predefined, simple, understandable tasks where the effect of independent variables on one dependent variable is measured in a specific manner and analyzed in a quantifiable way [88].

Experiments allow the systematic evaluation of the effects of alternative designs of the functionalities of an artifact. The main purpose of using experiments is to identify the most effective alternative solution for specific problem [165]. The level of systematization makes experiments an appropriate method for the evaluation of a newly developed artifact [165].

Experiments allow the systematic evaluation of the effects of alternative designs of an artifact's functionalities. The main reason to carry out experiments is to identify the most effective solution for specific problem [198], see Chapter 6. Next, an experimental design is created. In the last phase, during data analysis, the researchers perform quantitative data analysis, see Figure 7.1. Although experiments are acknowledged as a valid research approach for the evaluation of a DSR artifact, there are only a few well-defined and accepted guidelines on how to set up an experiment for DSR specifically, and how to present the results as an evaluation of the DSR artifact ([165], [134]). Due to the absence of guidelines, different experimental designs can be found. Chen and Hirschhein [55] state that the majority of experiments that are part of a DSR are held in a lab setting (artificial) where various subject groups test specific solutions. The absence of specific guidelines on how tp carry out an experiment requires a detailed report of all the activities undertaken. Mettler, Eurich and Winter [165] describe experiments as a process of three steps: the *pre-experimental* (i.e., preparation of the experiment), the *actual step* (i.e., during the experiment), and the *analysis step* (i.e., analysis of the results). The rest of the chapter presents these three steps

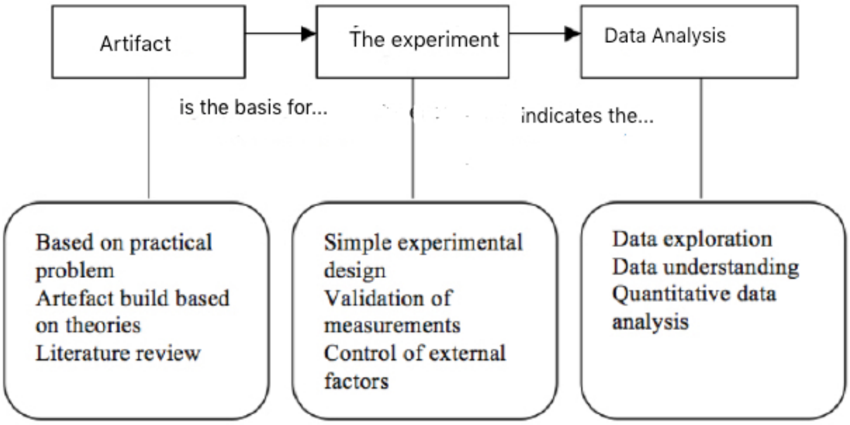

Figure 7.1
Experimental research framework in Design Science (adapted from Ge and Helfert [96]).

in detail.

7.3 Evaluation Outline

7.3.1 Preparation for the evaluation rounds

Preparations for the experiments included the identification of the hypotheses to be tested, the experimental design, the measurement approach, the validation, and additional actions we had to consider before the implementation of the experiments with participants. The following subsections present the preparations for the experiment in more detail.

We prepared the experimental design and identified the hypotheses to be tested, the scenarios we would use, the roles needed for the experiment, the ethical considerations we had to take into consideration, and we identified the used measurements to use and our actions to improve the validity of our experiment. In the first evaluation phase, we evaluated the experimental design with various informants. In the intermediate round, we reflected on the results from the first evaluation round and revised the experimental design and the artifact. Also, we considered alternative settings for the experiments. Finally, we performed the second phase evaluation and analyzed the data.

7.3.2 Hypotheses

The purpose of experiments is to test specific and prior defined hypotheses to confirm or reject them. The research assesses the effect of an independent variable on a dependent variable [165]. The purpose of our research was to evaluate the effect of the functionalities of the artifact on business model exploration. More specifically, we wanted to test the effect of previously identified hypotheses (Chapter 5) on the business model exploration in an experimental setting:

DP1: *Pre-filled business model templates, facilitate the users' understanding of the components of the current business model.*

DP2: *Templates with solution-based patterns, improve idea generation on how to change different components of the current business model.*

DP3: *Assessment features, improve users' decision making about whether to adapt components in the business model.*

7.3.3 Experimental design

The purpose of an evaluation is the main factor that drives the evaluation design. There are four types of experiments: true experiments, natural experiment, naturalistic experiment, and quasi-experiments. True experiments have more than one created group (control and treatment), specific measured outcomes and randomization. Researchers do not conduct natural experiments -these experiments happen in nature, while naturalistic experiment is conducted outside a lab setting. Mettler, Eurich and Winter [165] found out that 46% of the DSR evaluation experiments are quasi-experiments. For our study, we followed the experiment approach.

One simplification of our experimental design is the use of one single treatment and not the use of a placebo treatment. That would have allowed us to see how our exploration-specific tool outperforms the existing ones. However, our literature review did not find artifacts specifically developed for business model exploration. Another reason is that we wanted to test three design principles, and that would have required six versions of the artifact (with and without the functionality), which in turn would have required the participants to use more than one version of the artifact. That could have risked the success of the experiment.

Thus, the participants were assigned only to a treatment condition. Following the approach by [195], we collect data and we measure before and after the use of the artifact, see Figure 7.2.

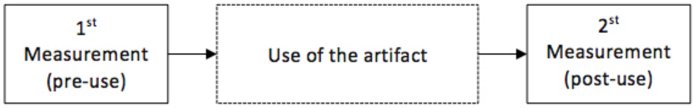

Figure 7.2
Outline of the experiment.

7.3.4 Scenarios

The difference between experimentation and observation is that experiments require the researcher to manipulate the cause of the phenomenon under investigation [165]. Scenarios allow the researchers to collect specific views, and provide end-user experiences of a situation [14]. Scenarios are important because they can prevent confounding factors (e.g., selection-maturation interaction effect, some users may have certain interests that lead them to use the tool in different ways) that could lead to different outcomes. To ensure that our participants utilized the artifact appropriately, we created a scenario with specific tasks that the participants had to perform.

In Chapter 4 we discussed the fact that enterprises within the automotive industry are increasingly changing due to new technologies, and that that leads to business model exploration. We, therefore, developed a scenario about a non-existent car leasing company. While the company we described is fictional, we based the scenario on real car leasing companies. The scenario was divided into three tasks. Each task was created so that the participant could use each of the functionalities of the artifact as they were described in Chapter 6 6. To support the second step of the artifact (regarding the IoT changes), we enriched the scenario with elements that required the users to think about how a traditional mobility service industry could earn value from the IoT. The subjects performed the tasks to create the existing business model of the car leasing company (based on a given description), to brainstorm how the business model can change in the case of a technology disruption (i.e., the IoT), and to assess these changes. The full scenario is presented in the appendices.

7.3.5 Roles

Conducting experiments requires specific roles. The researcher is responsible for the whole experiment. He or she is responsible for designing the experiment, the artifact, organizing the experiments, testing the experimental design, finding the participants, and collecting and analyzing the data. The researcher is also responsible for providing an introduction to the experiment's participants. The last role to be fulfilled is that of the participant. Participants in experiments are a group of individuals who have at least one characteristic in common. For our experiments, the characteristics in common were (pre-screening) that potential participants had:

- to be available for the experiments;
- to be computer literate;
- to be able to read English;
- to have an interest in entrepreneurship (student, researcher, entrepreneur, employee);
- to be at least 18 years old;

Our participants were entrepreneurs, employers, students, and researchers. In the following sections of this chapter, we provide more details about the participants and their characteristics.

7.3.6 Questionnaire items

Items to measure the effect of independent variables

Kampling, Klesel and Niehaves [132] state that questionnaire-based surveys are the most preferred evaluation method for conducting experiments, because the same questionnaire can be used before and after and compare the results for the two measurements. For the evaluation of the developed artifact, we followed the same approach. While observations were considered an alternative or additional data collection method (e.g., with observations we could have counted the ideas that came out of the use of the artifact), it was not feasible to use the method throughout the evaluation process as some experiments were conducted via online platforms. Additionally, following the approach of [64], the participants in our experiments were asked to, individually, fill out a pre- and a post-questionnaire. We followed this approach to evaluate the functional requirements of the developed artifact. As we wanted to evaluate the effectiveness of the functional requirements of the artifact, the pre-and the post- questionnaire included the same set of questions, which allows comparing and analyzing to identify to what extent the artifact contributes to the business model exploration.

DP1: Because a measurement scale for this variable is not available, we decided to adapt the '6 Facets of Understanding' scale [231] scale. Wiggins and McTighe argued that designers can determine the level of learners' understanding of the use of these six facets. We (as the designers) wanted to estimate the participants' level of understanding regarding the business model components.

DP2: Idea-generation for potential changes to business models can be described as the creative process of creating, developing and communicating abstract, concrete or visual ideas. The process includes all the steps from coming up with the idea of developing and realizing it. However, there is no general set of metrics to measure idea generation because there are many different types of idea generation activities [104]. To develop a scale for measuring the idea generation, we adopted the scales provided by [27] who created a scale about measuring creativity. Creativity is not equivalent to idea generation, but it could serve as a proxy for idea generation. We assumed that idea generation is a creative process and that we could use 'adapted' measurements of creativity for idea-generation.

DP3: Business model components are created and revised at different moments during the development process [75]. Developing a business model is thus is a dynamic process [203] that involves decision-making under uncertainty. Similar to DP2 measurements, we could not find pretested and predefined measurements for decision-making, so we revised the measurements developed and tested in [27] to measure decision making. We discuss the reliability of the measurements later in this section.

After the analysis, the final versions of the pre- and post-questionnaires were developed. The pre-questionnaire included some questions about demographics (which would help us to decide whether the data were appropriate for analysis). See the appendix for the full list of the questions in the pre- and the post-questionnaire.

7.3.7 Validity

When designing an evaluation method, it is important to pay explicit attention to validity. Reporting validity decreases the likelihood of biased research results and also increases transparency. Regarding experimental design, there are four types of validity to consider: *internal validity, external validity, construct validity, and statistical conclusion validity* [71].

Internal validity concerns whether the causal relationship between a dependent and an independent variable is true and established [235]. If a study shows a high degree of internal validity, this causal relationship can be confirmed, while if a study shows a low level of internal validity, the causality will be rejected because the results are affected by uncontrolled variables [71]. There are eight threats that affect internal validity: *testing* (pretesting the subjects may influence the performance), *history* (unplanned events that may occur during the study), *maturation* (biological, natural, or psychological changes such as boredom or tiredness), *instrumentation* (changes in the testing instrument may affect what is measured and what is not), *experimental mortality* (subjects drop out of the study), *selection* (subjects are selected in a non-random way), *regression to the mean* (extreme results that affect the meaningfulness of the pre- posttest comparison), and *selection method interaction* (the selected method might interact with other threats e.g., students may be impacted by maturation more than practitioners) [85].

External validity concerns how generalizable the research findings are to other populations, settings, and a broad population Two threats to external validity are the use of *specific participants*, and *restricted number of participants* [85]. [86]. External validity can be increased if the same experiment is carried out across different participants and settings [71]. Other ways to increase external validity include using complex sampling procedures and carrying out repetitive studies. It should be noted that another threat to external validity may be the *internal validity.* The more artificial the experimental design, the less realistic the results.

Construct (content) validity should be considered when a self-report measurement instrument is used (e.g., a questionnaire). The measurement instrument used needs to be inclusive and capture every element of what is being investigated. In the case of the questionnaires that mean the questions need to be related to the constructs measured. Threats to construct validity are *irrelevant questions, confusing wording and design*.

Statistical conclusion validity means that the variations in the dependent variables are due to the variations in the instrument used, and not to variations in the subjects. In general, the statistical conclusion validity concerns the quality of the instrument and the statistical assumptions. For instance, statistical conclusion validity might be violated if the instrument is unreliable or if data have been treated as a different type of data (e.g. ordinal data treated as numerical). In other words, there is statistical conclusion validity if the study conclusions are drawn after statistical laws are followed, such as variation of cause and effect and statistical power.

An important aspect of any experiment is the ***reliability*** of the measurement. Reliability can be achieved when the measurements, under the same conditions, produce the same results [85]. However, for a questionnaire to be valid, it first needs to be reliable. We presented the developed measurements to key informants and collected their feedback, thus establishing face validity. The questionnaire was then pilot tested with them in focus groups and experiment Finally, we explored the data and based on the data exploration we concluded in the final version of the questionnaires.

In Tab7le 7.1 we present the actions we took during our study to strengthen the validity and reduce the effect of the threats.

Table 7.1
Threats to, and the actions to strengthen the validity during the evaluation.

Threads to...	**Actions to strengthen validity**
...internal validity	
Maturation	Completion times$<$ 20mins and $>$70 minutes were not included in the analysis.
Testing	This is unavoidable since we use the same items pre and post.

Continued on the next page

Table 7.1 – continued from the previous page

Threads to...	Actions to strengthen validity
History	(a) For the workshop settings, we controlled unplanned events by having observers to watch server for any unplanned events. (b) To control unplanned events via crowdsourcing marketplace, we set a specific period (40-70 minutes) that they could use the artifact and provide answers to the pre- and the post-questionnaires. (c) To control unplanned events online was more challenging. In that case, we evaluate the time that tool the participants to fill out the pre- and the post-questionnaire. The time span was chosen based on observations during the first phase evaluation.
Instrumentation	The instrument was the same for every test in the same evaluation cycle. It should be noted that the instrument used for the second evaluation round was a simplified version of that used for the first cycle.
Selection	The majority of the subjects 'self-selected' themselves. That means the respondents were those that were more interested in BMI, or that were more eager to learn, or that liked to use tools.
Regression to the mean	Extreme results were excluded from the analysis if the qualitative data did not indicate any logical reason behind the results.
Selection method interaction	We performed the analysis only within the groups (an not between groups) or across the whole dataset.
Experimental mortality	We targeted more participants than the sample size needed. 32 participants dropped out all from a specific setting (crowdsourcing platform)

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Table 7.1 – continued from the previous page

Threads to...	**Actions to strengthen validity**
...external validity	
Use of specific participants and setting	The participants were enrolled via different channels and they had different characteristics. We compared the results of each group to the other groups to test the validity of our results in.
Restricting the number of participants	The number was based on the statistical power.
Artificial setting	While an artificial setting might cause issues related to the external validity, we used a relatively artificial setting for evaluation because it gave us more control over possible confounders.
Internal validity as a threat	We worked on balancing the internal and the external validity taking into consideration (and making decisions) on what could affect each other.
...construct validity	
Measurement instrument (pre- and post-questionnaire)	An extended version of the questionnaire was used at the first cycle evaluation. Then a revision on the pre- and post- questionnaires took place.
Irrelevant questions	Irrelevant or confusing questions were omitted from the second round evaluation based on the feedback from the first round evaluation.

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Table 7.1 – continued from the previous page

Threads to...	**Actions to strengthen validity**
Use one source of evidence	In general, we only used one source of data collection (i.e., questionnaires). In the case of the lab setting experiments, we collected observations too. The collected observations are not however sufficient to conclude upon.
Layout and wording	(a) Prior to the experiments, the experimental design was presented to experts for a discussion on what might be confusing. (b) We did a pilot test to improve the layout and the wording of the artifact, the experimental design, and the questionnaires. (c) The post-questionnaire had an open question asking for additional feedback from the participants. (d) The observers noted down any comments they received related to the wording and layout.
...statistical validity	
Statistical power not taken into consideration	We calculated the statistical power for different confident intervals, β error and, decided upon the best option for our study.
Data treated in a wrong way	A researcher (other than the principal researcher) supervised the analyses and checked the intermediate results.
Not estimated confidence interval for the analysis	We used a 95 percent confidence interval and we calculated the results basline.

7.4 Evaluation rounds

7.4.1 First round evaluation

The first evaluation round was held immediately after the development of the artifact. The purpose of this round was twofold: first, we wanted to test the artifact and our evaluation approach, and based on the results to improve them for the next round; second, we wanted to draw initial conclusions concerning whether the hypotheses were confirmed or rejected 7.3. During this round, we performed four activities. This evaluation round lasted for five months. After each activity, we reviewed the feedback and revised the artifact or/and the evaluation process. Below we explain each activity in detail.

In the first evaluation round, the data were collected in various ways, from different informants, at different locations, and for different purposes. See Table 7.2 for a detailed description of the participants and the setting of the first evaluation. Here, we discuss the results of the first round evaluation. A detailed description is presented below.

Table 7.2
Details of the data collection from the first round evaluation.

Actions	Informants	Duration and Location	Number of participants	Focus of the feedback	Data collection methods
Alpha testing (a)	Software developers	30mins; Online	4	Technical requirements	Short questionnaire
Internal pilot testing (b)	PhD researchers	1hr, workshop setting (the results from this workshop were used only for piloting the evaluation approach)	10	Informal testing of the prototype and the methodology for improvements	Focus group for internal use only (Not reported here)
Beta testing (c)	Technology consultant, and business consultants	1-2hrs; Online (via Skype); face to face meeting	4	Principles, Functional and non-functional requirements	Interviews
Experiment (d)	Students with entrepreneurship focus	1.5hr (Lab setting)	23	Use of the tool to test the process of evaluation	Pre- and Post- questionnaire, observations
		(Total)	41		

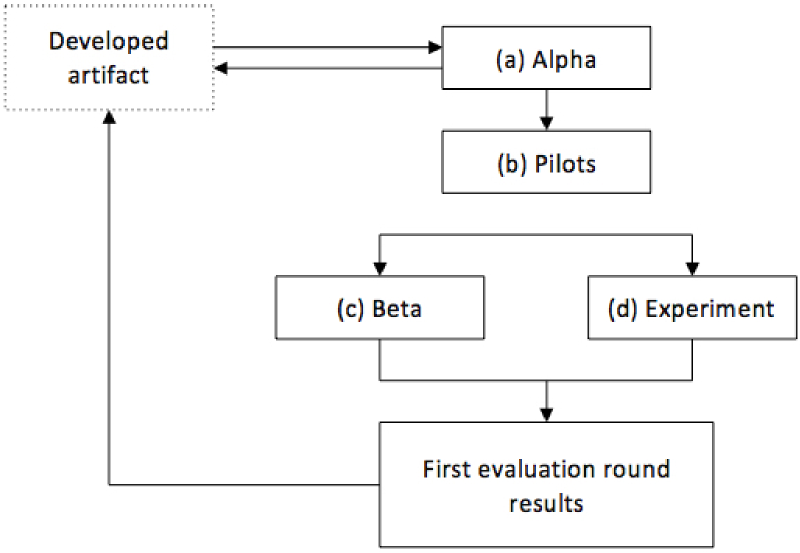

Figure 7.3
A detailed illustration of first round evaluation.

Alpha testing (a)

Initially, we asked software developers to alpha test the prototype. The aim was to identify any major or minor technical issues. The alpha testers used and tested the prototype, and then completed an online accessible questionnaire. We asked questions regarding major and minor technical faults (e.g., bugs), time estimation, and the response of the tool in different actions. The alpha testers, as software developers from our network to test the artifact and then to fill out an open-ended simple questionnaire. The alpha testers, as software developers, only focused only on the non-functional requirements of the artifacts. Hence, the experimental design and functional requirements were not tested.

Pilot Testing (b)

The next activity was to pilot test the evaluation approach. We recruited junior researchers from our network and asked them to perform the tasks of the scenario, as previously described. The pilots provided feedback for the improvement of the business model tooling and the evaluation process. Data from this activity were not analyzed to test the hypotheses. We performed three sessions with 10 participants in total. A room was arranged for that purpose. We first explained the purpose of the research to the participants; the testers were then able to ask questions. The testers were able to provide feedback, comments, and other recommendations on paper or directly to the researcher who facilitated the sessions. The pilot tests were only for internal use and for making improvements based on of the feedback, and therefore the results from the pilot testing are not analyzed or discussed in this chapter.

Beta testing (c)

For the beta testing, we asked the opinion of four consultants experienced in business models and technology disruption. The researchers presented the prototype to the beta testers. During the discussion, the beta testers provided their comments. The purpose of the beta test was to test the artifact outside the developer's environment. For the beta testing, a set of tasks that the beta testers would be asked to perform needed to be created. After the beta testers finished the task, they were asked to fill out a survey regarding reliability, performance, usability, user satisfaction, speed, easiness, and wording. We conducted beta tests via Skype or face to face.

Experiment (d)

The participants were invited to a computer lab. The scenario was available in a digital form on the computer in front of them. A facilitator (from outside the research team) was present throughout the process and observed the participants while they continued with the workshop and the scenario. The participants had an allocated time (120 minutes) to complete the scenarios and complete the questionnaires. While allowing them only 120 minutes was somewhat optimistic of us, it allowed us to collect completed questioners from all the subjects. Three experiments were held in which 23 Master's (MSc) with an interest in entrepreneurship used the prototype and provided comments. For ethical reasons, where possible, we asked persons, uninvolved with this research, to be part of the workshops as facilitators of the workshops. The facilitators provided observations of the workshops that were used to validate the evaluation and for future improvements.

7.4.2 Improvement of the artifact and the experimental design

The results from the first round evaluation were then processed to improve the artifact before the final evaluation. The purpose of this round was to implement the improvements based on the feedback we collected during the first round. Based on that feedback, we revised the artifact. We prepared the experiments for the second round evaluation. The intermediate round lasted for seven months. During the intermediate round, we:

- Analyzed the data from the first round and presented it to the academic community during academic conferences.
- Revised the artifact according to the qualitative feedback we received.
- Prepared the experimental design for new settings (described in the following section.

An experiment was also conducted in a lab setting. The aim was to pretest the revised experimental design and artifact. The experiment was part of an intensive course for students following an entrepreneurship syllabus. During the experiment, the observations were collected and questions about the process that were then analyzed to improve the experimental design and the artifact. We did not analyze the data collected from the pre-test because we made some adjustments to the experimental design and the artifact. These adjustments did not allow the analysis of the data from the pretest to be analyzed with the rest of the data from the second round iteration.

7.4.3 Second evaluation round

The second round evaluation took place immediately after the intermediate round where we revised the evaluation approach and the artifact. The purpose of the second round was to test our hypotheses, see Figure 7.4. During this round, we undertook four activities (e-h).

An important aspect of any experiment is to estimate the sample size of the participants, which allows one to appropriately analyze the data with the minimum error and then generalize the findings to the whole population. To do so, we calculated the statistical power (with the use of G*Power program [85]) for a paired t-test. We assumed effect size of 0.3 and a 1-β error probability (type II error) of 0.95. That led to a sample size of 125.

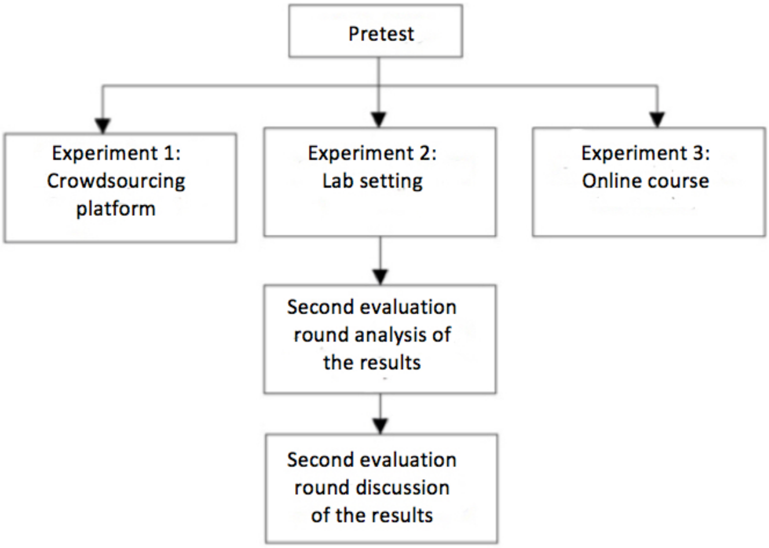

Figure 7.4
A detailed illustration of second evaluation round.

Based on the statistical power, we recruited a number of participants that exceeded the minimum sample size. While the experimental design was the same for all the activities, some alterations to the presentations and other characteristics needed to be made. This evaluation round lasted for six months. Below we discuss the main setting of the summative evaluation (i.e., crowdsourcing community), and the additional participants' pools we used to validate the results. Below we explain activities e–h.

Main setting: Crowdsourcing community (f)

The first and main setting for experiments was the use of the crowdsourcing community. Online labor communities can serve as a platform for experiments, as they allow people from around the world to perform specific tasks that are remotely manageable [93]. These platforms allow immediate access to a large subject pool while also allowing the researcher to control the context and the internal and external validity [122]. Within just five years (2011–15), the number of studies conducted via online workforce platforms grew from 61 to 1,200 [36]. This growth can be explained do to the fact that these platforms offer short-time recruitment, access to broader populations (than lab experiments with students), potentially with less cost, and reliability (studies replicated lab experiments via crowdsourcing communities) [182]. Additionally, previous research found that the participants are part of these communities due to (and in addition to the monetary reward) internal motivations such as enjoyment [148]. These platforms have some specific characteristics—such as individual-specific payments, pre-screening, and participants cannot communicate with each other—while allowing better validity [122]. However, a challenging aspect of some of the well-known crowdsourcing platforms is that they were not specifically designed for academic purposes [182].

Prolific (`Prolific.ac`) is a crowdsourcing community that was recently developed explicitly for research purposes. We chose the use Prolific.ac platform as it provides clear rules for both researchers and participants, as well as transparency for both researchers (e.g., information about the subjects, pre-screening) and the participants (e.g., on the subject of the experiment, payments, and obligations) [182].

We used the Prolific platform for the experiment. A short introduction was given, so all the participants received the same common knowledge [122] explaining what is the purpose of the experiment. To prevent the same participants participating in the reruns of the experiments we added pre-screening question about the participation in previous versions of the experiment, see Figure 7.5 for an overview of all the pre-screening questions). For the experiment, the estimated completion time was 40 minutes and the maximum time spent completing the experiment was 70 minutes. We arrived at this time based on the observations we collected during the first phase evaluation: The participants spent between 35 and 55 minutes working with the experiment. After that the session was timed-out and the participants could not get their reward, that is, 5.5 euros, which the platform regards as a fair reward for participants. Also, at the post-questionnaire, a completion code was added that the participants had to enter before their final submission, see Figure 7.6.

The time spent on the experiment determined whether the data would be analyzed. We decided to only include the data of participants who spent more than 30 minutes on the experiment. That time was decided upon because, in the first evaluation phase, the average time spent on the experiment was 40 minutes. While it was not planned as such, due to the period during which the experiment was open for new participants, the principal researcher was able to be online and answer

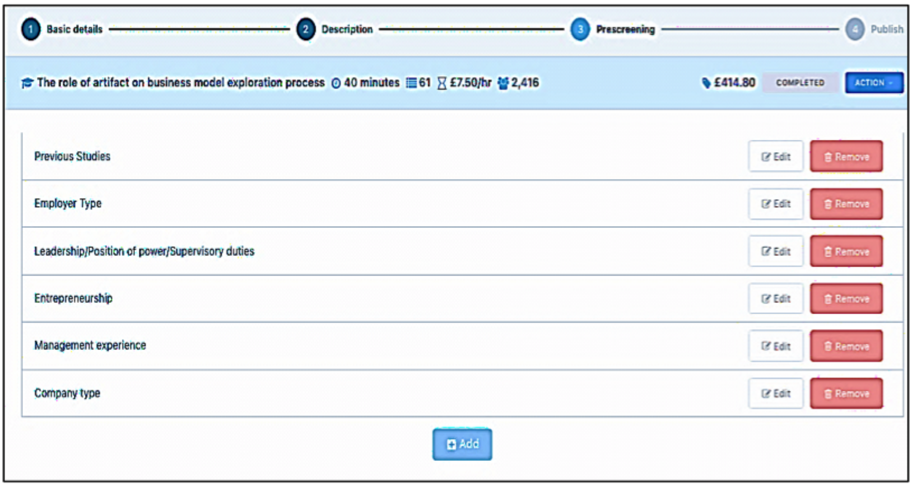

Figure 7.5
Pre-screening questions (screenshot taken from Prolific.ac).

the 10 questions the participants asked via the platform, see Figure 7.6.

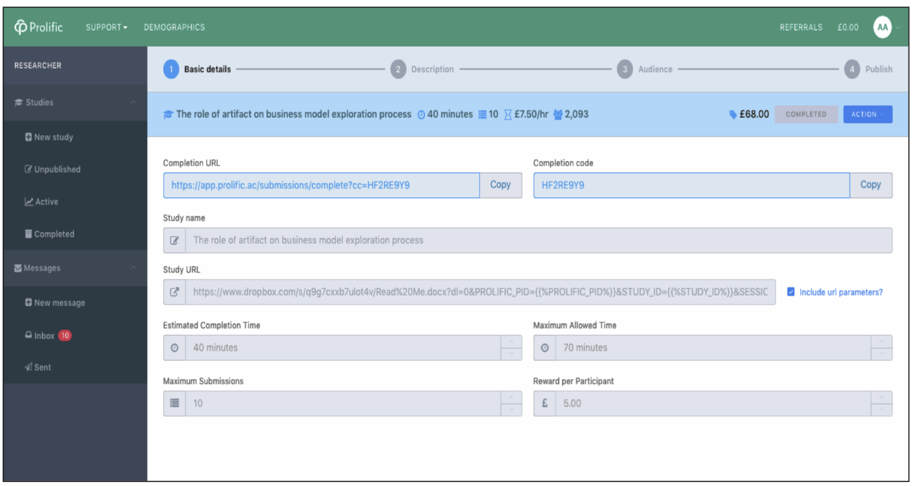

Figure 7.6
Screenshot presenting the basic details of the experiment (screenshot taken from Prolific.ac

Additional settings

The crowdsourcing platform was the main participant pool for our research. However, to improve our external validity we used different settings and participants in the following experiments. Below, we provide detailed descriptions of the two additional settings, namely a *lab setting*, where Master level students were the participants, and an *online course* aimed at professionals who want to learn about business model innovation. Below, we provide detailed descriptions of the settings. The Online course was a preferred setting as it combines the online platform (as a confirmation setting for the crowdsourcing platform), with practitioners who want to advance their knowledge on business models. Additionally, we had access to students that have an entrepreneurship focus, and interest on the business models but at the same time they are not professionals with experience on BMI.

Lab setting

The lab setting experiment, took place at Delft University of Technology (Delft, The Netherlands) experiment was voluntary and even if the students participated they could decide whether their data would be stored and analyzed and that their participation or non-participation would not have any impact on their grade. The principal researcher made an oral and a written announcement that this experiment was not part of the course and that the students could withdraw at any time without any consequences for their grade. Finally, as a reward the students were given a monetary voucher they could use in a large online store.

Facilitators were present in a lab setting. The facilitator was not involved in the development of the artifact or the design of the experiment. Different people took the role of the facilitator. Bedore the experiments, the researcher and facilitators/observers had a meeting, during which the researcher gave instructions to the facilitator. During the lab experiment, one facilitator was present in the class throughout the process, observing, and noting, what the participants were doing. The observations were used to the improvement of the artifact. The researcher told to the participants that they would keep the voucher even if they did not complete the experiment or did not want their data to be processed. Because the experiment was a part of the course, the students were asked to work on the scenarios alone for 45-50 minutes (more if it was needed). During this time the participants individually used the tooling, followed the scenarios tasks, and completed the questionnaires. After they had completed the post-questionnaire, they had a 15-minute break. The session ended with a group discussion about the participants' results and experience, each group comprised three participants. These discussions were not recorded or analyzed as they only served educational purposes. The principal researcher was available the whole time as the facilitator of the process and observer of the situation but did not intervene in the process in any way. The participants were given an instructions document and an ID number, and when they were done they were asked to go to the facilitator for their reward. Figure 7.7 presents the layout of the lab setting.

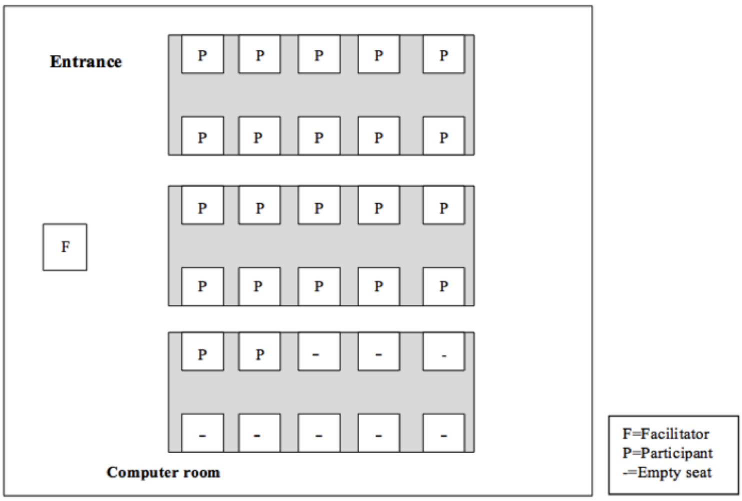

Figure 7.7
Layout of the computer room used for the lab experiment.

Online course

The next setting was a massive open online course provider (MOOC) (`EdX.org`) as part of a recurring course titled 'Introduction to the business models'. Because this experiment was part of an online course, we had to re-format the experimental design to fit a lecture (namely a 'block') layout following the instructions of the platform. Besides, a video was developed that briefly explained the purpose of the experiment replacing the introductions used in experimental design (`https://www.youtube.com/watch?v=r2lu6tgon2A`. In this case, the experiment was introduced as an assignment. The participants who were pursuing a (paid) professional certificate, received feedback on their assignments, and if they ran their own business they were welcome to submit the assignment using their own business (and received feedback upon it). Because this course is self-paced, a specific deadline is not available concerning when the participants should submit their assignments. Thus, we only included the data we received between September 1 (launch day) and December 30, 2018. Figure 7.8 presents a screenshot from the course developed based on the experiment as a part of the Edx.org platform.

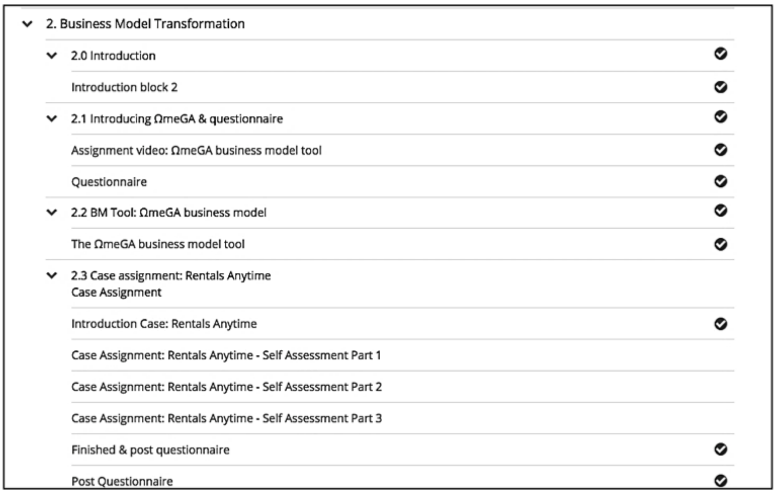

Figure 7.8
Layout of the EdX.org block used as setting for the research (screenshot taken from EdX.org).

The data of 192 of the 348 participants were analyzed. The data of the other participants were not analyzed, either because they did not give their consent for their data to be analyzed and stored, or because the researchers decided that the data were not appropriate for analysis (e.g., some people completed the two questionnaires in less than 15 minutes). The large majority of the online course participants did not give their consent to have their data processed for scientific purposes, we assume because they did not want to expose their personal and business-related data to the public. Table 7.3 provides an overview of the participants in the second round evaluation.

7.5 Analysis phase (Results)

7.5.1 Results from the first round evaluation

We first discuss the main comments we received from all the informants and then focus on the findings on the three design principles.

The alpha testers (a) identified some technical problems and some bugs. The layouts and color codes were well received but some improvements can be made. Their recommendations were immediately processed.

Table 7.3
Details of the participants from the second round evaluation.

Informants	**Setting**	**Reason to participate**
Entrepreneurs/ Researchers/ Students	Crowdsourcing evaluation (Prolific)	5.5 euros as a reward
Students	Lab setting (France)	Part of a course (Participation voluntary)
Practitioners	Online course (Edx platform)	Part of a course (participation voluntary)
Students	Lab setting (the Netherlands)	Voluntary participation and 10 euro voucher as a reward

All the beta testers (c) acknowledged that the tool is useful and that the pre-filled option is an interesting feature. Two of the beta testers said that the illustration of the existing business model (step 1 of the artifact) should always be visible so that users can identify potential changes to their existing business model. Three beta testers suggested that at the next version of the tool, and more specifically the second step of the IoT transformation, needs to include more options regarding the disruption needs to be included in order to support the users with the business model transformation, and offer more value to the users and support them more with their next actions regarding their business model exploration. It is interesting that all the beta testers extensively commented on the last step (assessment of the changes). They said that this step requires a lot of time and that users might not find that appealing. Also, they said that the same metrics cannot be used for each potential change. Finally, three of the beta testers suggested that the artifact needs to provide a final recommendation to the users in the form of a prioritization list of the identified changes. One of the beta testers argued that this will contribute more on the users' decision making because they will have some concrete actions to do in the near future. All the beta users argued that the artifact needs to be more automated (e.g., to give suggestions, to prioritize without requesting the users to do it on their own, etc.). One of the beta testers pointed out that the open questions should be eliminated because users prefer to brainstorm and decide upon specific recommendations.

Regarding the outcomes from the experiments (d), feedback that we received from the majority of the participants was that a clear description of the purpose of the business model tool was needed to be able to work with it. Also, some of the participants said they found the third step (where they had to assess the potential changes) too demanding and indicated that they had expected the tool to require fewer inputs from them.

Finally, we analyzed the facilitators' observations. From the observations, it was clear that the participants were engaged in the process and the use of the tool. However, the observers noted that the informants had some issues with understanding of the wording, that the process was time-consuming, and that the layout of the prototype could be improved.

We wanted to see whether the findings indicate that the design principles, that informed our prototype, contributed to some extent to the business model exploration. The alpha testers did not focus on the functionalities of the prototype and hence the findings from this activity did not provide any indication regarding the design principles. Table 7.4 summarizes findings of and suggestions from the beta users, supporting the choices regarding the design of the prototype, and indicating points of improvements (findings, suggestions).

Table 7.4
Initial findings and suggestions form the informants regarding the design principles (DPx) from the first round evaluation.

	Regarding DP1	**Regarding DP2**	**Regarding DP3**
Findings	'Pre-filled is a perfect idea' (beta tester 1). The pre-filled option is interesting as it is not a common feature on the design of existing business model tooling' (beta tester 2).	'What I don't like: you put the user to think the transformation. This is the job of a consultant Also, I am not sure if they will understand that you give them inspiration and not a specific solution. However, they will get inspired' (beta tester 1).	'If it is designed well then it can really help the users to make decisions' (beta tester 3).
Suggestions for improvements	'Where are questions regarding the costs?'(beta tester 3 and 4).	Support them by providing questions. Provide an overview, for example: 'Do you think that it will be profitable?' (beta tester 4).	Prioritization of the assessed changes is needed so users can make decisions (overall comment).
What we changed	We added questions regarding the finance. We simplified the elements, and we revised the wording.	We simplified the layout of the tooling, and we added questions. However, when we revisided we were not able to have automated suggestions regarding the transformation. Based on the suggestion by the tester 3, we revised the questions regarding the IoT transformation.	We looked at the literature and we only used several assessment criteria following the prioritization recommendation, We revised the layout in a way we thought would increase the usability

7.5.2 Results from the second evaluation round

Data Preparation
IBM SPSS Statistics version 25 was used to prepare and analyze the collected data. Below we present our analysis.

Description of participants

Of the 192 participants who gave us consent to analyze their data, the majority (65,6%) participated via Prolific.ac, 22.9% participated via EdX.org course, and 11.5% participated in the lab setting. The majority of the participants gave their occupation as 'employee'. The next most common occupation was 'student', which makes sense considering that 22.9% of the participants were recruited via an MSc course. The third category comprised of entrepreneurs/business owners. Researchers also participated in the experiment and did so exclusively via Prolific. Finally, some participants gave 'Other' as their occupation, see Table 7.5.

Table 7.5
Details of the participants from the second evaluation round.

Daily occupation		**Number**	**of participants**	
	Crowdsourcing platform	Online course	Lab Setting	Total
Employee	85	15	-	100
Entrepreneur	9	13	-	22
Researcher	6	4	-	10
Student	23	5	23	51
Other	3	6	-	9
Total number	126	43	23	192
Total in percentages	**66.6%**	**23%**	**11.4%**	**100%**

Prior experience with business models

Participants were asked about their experience with business model frameworks and the majority stated that they were familiar with the concept of business model frameworks (μ=3.38, σ=1.91). Although the results indicate that participants recruited via Prolific were on average more experienced in BMI, they gave the least diverse answers. Participants in the lab setting experiment had the least prior knowledge of BMI. That is likely to be because all the participants were students and they might be less familiar with the term. Figure 7.9 presents the results of BMI knowledge per daily occupation (1=no prior BMI knowledge, 7=excellent BMI knowledge). From the figure, we can see that there is a consensus between employees with a moderate to high BMI knowledge. It is interesting, however, that a large percentage of employees said that they did not have prior BMI experience. As we expected, students said that they had moderate BMI knowledge, but their answers were still diverse. The rest of the occupations provided diverse answers. ANOVA test did not indicate a significant difference between the participants either of deferent settings (p=0.10) or between the answers based on the daily occupation (p=0.67). On the contrary regarding the familiarity

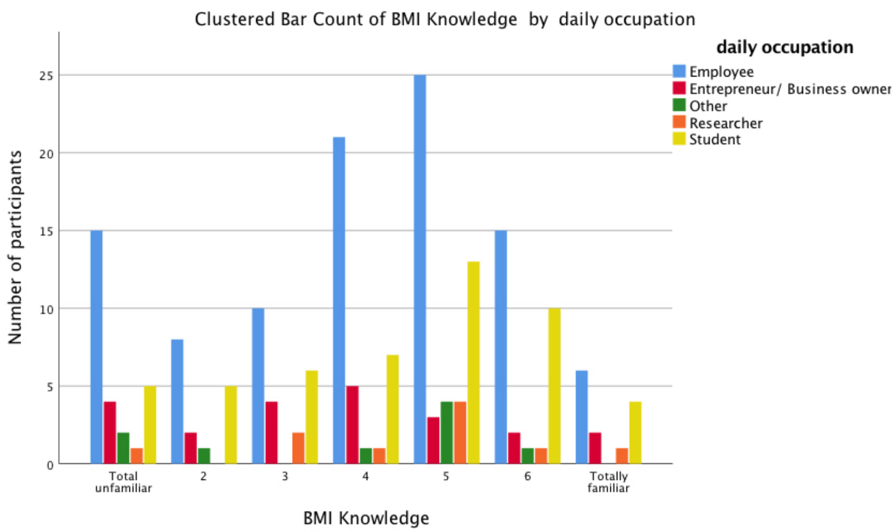

Figure 7.9
Business model knowledge per daily occupation.

with business model frameworks, ANOVA test indicated a significant difference between the participants of deferent settings (p<0.001), with the larger significant different to be between crowdsourcing platform participants and the participants of the lab setting. ANOVA test indicated a significant between the answers based on the daily occupation (p=0.002).

Regarding prior experience with business model tools, a large percentage of participants stated that they did not have experience with business model tools. On the contrary, the results of the students indicate that a large percentage of them were aware of business model tools, something that we expected due to the knowledge they had acquired from other courses in the curriculum. The majority of the employers said that they were aware of business model tools. However, we did not collect data on which tools they were referring to (see Figure 7.10).

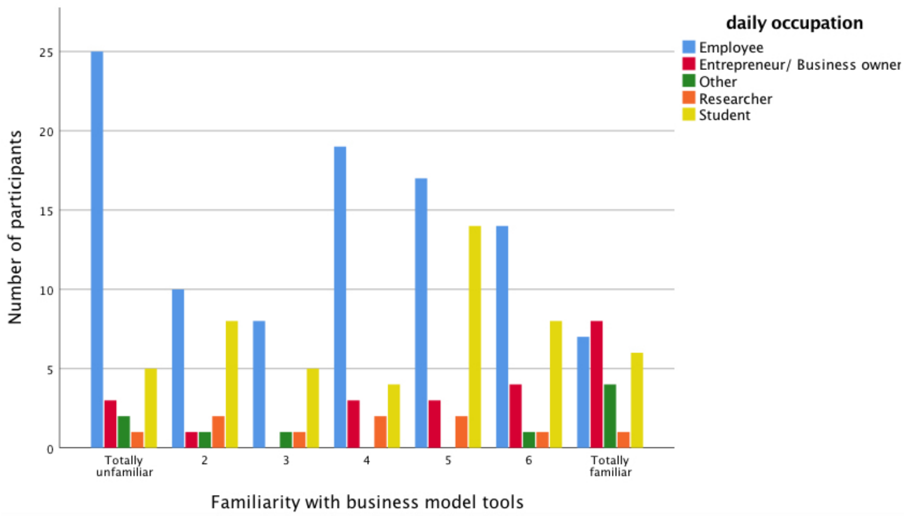

Figure 7.10
Prior experience of the participants with business model tools per daily occupation.

Regarding the familiarity with business model tools, ANOVA test indicated a significant difference between the participants of deferent settings ($p<.001$), with the participants of the crowdsourcing platform to be significantly more familiar with business model tool compared to the other settings. ANOVA test indicated a significant between the answers based on the daily occupation ($p=.03$). Employees are significantly more familiar with business model tools.

Data Exploration

We explored our data to identify potential problems. First, we created the histograms of all the variables. When we reviewed the histograms, no outliers were found. The next step was to inspect whether our data were normally distributed. To do so, we checked the P-P plots [85]), which showed that for all our values, the distributions were skewed left (negatively skewed). To further explore the distributions and decide upon the normality of our distributions, we checked the measurements of skewness and kurtosis. Variables were close to a normal distribution with absolute values of skewness and kurtosis below 1 for most of the variables. Our data were not severely non-normally distributed, hence parametric tests could be applied. We, therefore continued our analysis using statistical methods for parametric data. As the data exploration did not indicate any problems in the data (e.g., outliers), we continued the exploration of the results with the data as it was.

Results from the second evaluation round

We present the data for two samples. First, we present the results of all the participants from all the experiments we conducted. Then we present the results from the participants who took part via the crowdsourcing platform (Prolofic.ac). This group fulfills the sample size required for the statistical power and provides a homogeneous population exposed to the same experiment.

Pre-questionnaire results

The pre-questionnaire was used to identify: To what extent the participants were aware of the business models and understood the components; to what extent their existing familiarity with business models allowed them to generate new ideas; and to what extent they were able to make decisions regarding the business models. A mean score of 1 indicates a negative response to a statement in the questionnaire, 4 indicates a neutral response, and 7 indicates a positive response.

N=192 (All the participants)

Table 7.6 presents an overview of the means and standard deviations of the pre-questionnaire items for all the participants. Regarding the understanding of the business model components, we can see that participants were already largely capable of discussing the components of business models (μ=4.98, σ=1.63). The participants were similarly capable of explaining which components are relevant for specific cases (μ=4.93, σ=1.63). Furthermore, participants were less able to interpret the business model components (μ=4.83, σ=1.66). Finally, the participants were able to describe to a similar extent the components of a business model in their own words (μ=4.85, σ=1.58). From the above, we can conclude that the participants had a moderate to a good understanding of business model components. Overall, the means are largely similar, namely between 4.7 and 5.0.

Table 7.6
Means, and Standard deviations of the items of the pre-questionnaire (N=192, All the participants).

Item	**Mean**	**Standard Deviation**
Discuss components of business models.	4.98	1.63
Explain relevance of components of business models.	4.93	1.63
Provide solid interpretation of what business model components are.	4.83	1.67
Describe the components of a business model in my own word	4.85	1.58
Sufficient number of ideas on how to change an existing business model.	4.94	1.61
Creative ideas on changing an existing business model.	4.88	1.65
High quality Ideas on how existing business models can be changed.	4.77	1.55
Different ideas on how existing business models can be changed.	4.88	1.59
Make recommendations regarding business model changes	4.80	1.50
Make tradeoffs on what should be changed in a business model.	4.74	1.59
Identify the most effective business model changes. within a set of alternatives.	4.82	1.59

Next, we analyzed the results considering 'daily occupation'. We were interested in the results per occupation as their expectations and experiences might be different. For an overview of the spread of the answers for the four items, see Figure 7.11. Participants who gave 'researcher' as their occupation were more capable of discussing the components of a business model. These participants might have done research related to the business models field. Business owners (entrepreneurs) had similar results. These participants may have been exposed to the business models in practice while running their own business. The students' answers can be explained (and were expected) as they had already been exposed to the term during their studies. Finally, employees and other practitioners were less capable of discussing the components of the business models, which was also expected as business models are commonly discussed at the managerial level. Regarding 'explaining the relevance', the results are similar to before, the only difference being that entrepreneurs were more capable of explaining the relevance of the business models; the researchers were the second most capable. The other categories had similar distributions as before. As with the previous items, entrepreneurs were more capable of interpreting the business model components (μ=5.32, σ=1.52).

Next, participants were asked about their ability to generate ideas regarding business model components. As for having a sufficient number of ideas on how to change existing business models, participants said that they were relatively experienced. The participants also said that they were less able to generate high-quality ideas on how existing business models can be changed. The participants stated that they were also less able to generate creative ideas on what to change in an existing business model. Finally, the participants stated that they were highly capable of generating different ideas on how existing business models can be changed. Thus, the participants were moderately capable of making recommendations regarding business model changes. For an overview of the spread of the answers for the four items, see regarding occuption see Figure 7.12. Employers again said that they were capable of generating sufficient ideas, while the employees said that they were the least capable. The rest were somewhere in between, but still high. Entrepreneurs and other professionals said that they were highly capable of generating creative ideas. Researchers and students said that they were able to generate creative ideas to the same extent (but with small differences in the

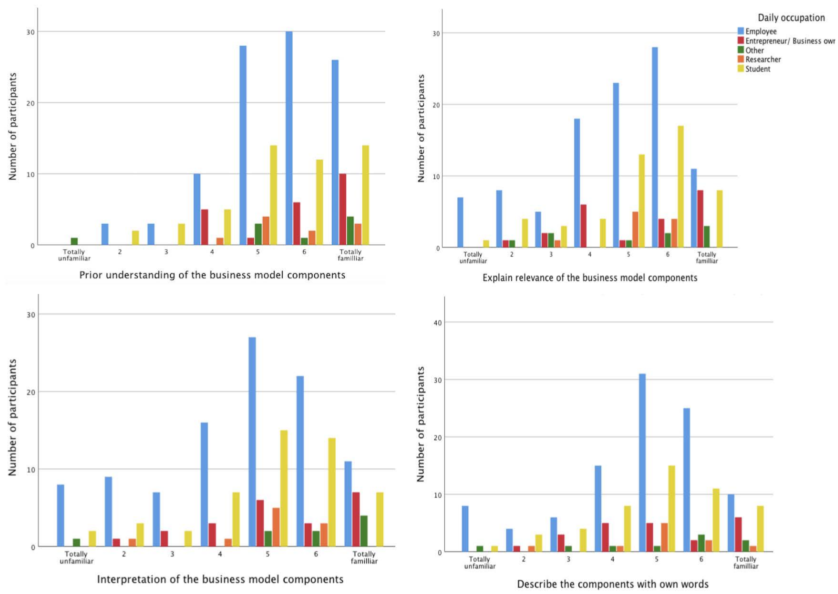

Figure 7.11
The spread of the answers for the four items related to 'idea generation'.

standard deviation). Employees again said that they were less familiar with creative ideas, but that they were highly capable of generating high-quality business model ideas. Similarly, employees said that they were not very experienced in generating high-quality ideas. The students and other professionals (μ=5.67, σ=1.73) said that they were highly capable of generating different ideas.

Finally, the participants were asked about the extent to which they were able to make decisions concerning the adaptations of business model components. The participants were moderately capable of making recommendations regarding business model changes. The participants were also moderately capable regarding their ability to make trade-offs on what should be changed in a business model. The participants said that they were able to identify the most effective business model changes from a set of alternatives.

We analyzed the results for daily occupation. For an overview of the

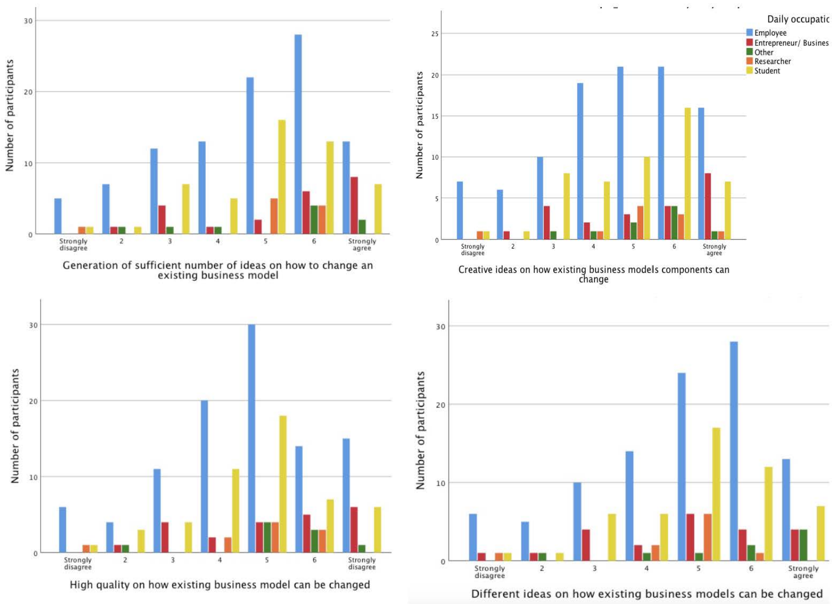

Figure 7.12
The spread of the answers for the four items related to idea generation related to 'Understanding of the business model components' per daily occupation.

spread of the answers for the four items, see 7.13. Entrepreneurs said that they were highly capable of making decisions about the adaptation of business model components. Employees were more moderately capable. A reason might be that they are the ones who make decisions, and they are modest with their answers. Researchers were more capable of making trade-offs and were highly capable of identifying the most effective business model changes from a set of alternatives, possibly again because of their scientific experience with the topic. Employees and employers were moderately capable of distinguishing appropriate business models. The similar results might indicate that in practical settings (e.g., corporations), making decisions about business model changes (from a set of alternatives) is not a common practice.

We performed ANOVA test to see if there are significant answers between the different setting and different daily occupations. The results

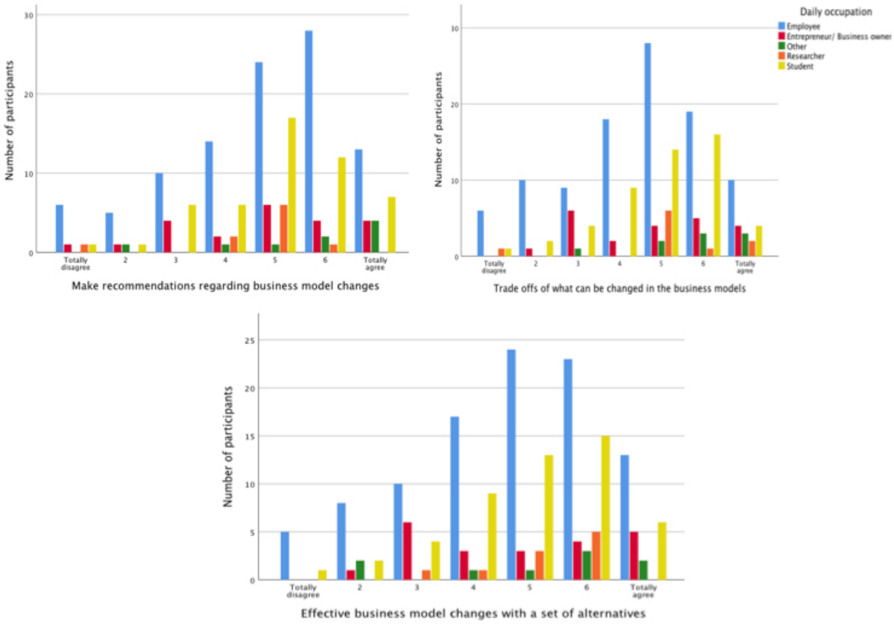

Figure 7.13
The spread of the answers for the three items related to 'decision making on which changes will be applied' per daily occupation.

indicate a significant difference between the different settings in relation to the *interpretation of the business model components* (p=.003), the *describe the components with their own words* (p=0.05), and *make trade-offs* (p=0.05). ANOVA test for the daily occupation did not indicate a significant difference in the answers.

Participants via Prolific.ac (N=126)

We discuss the results of the participants in the Prolific experiments as they fulfill the sample size. Of course, we did not expect large differences in the results, because these participants represented the majority of the total sample, see Table 7.7 for an overview of the means and standard deviations of the items in the pre-questionnaires (only those for Prolific are presented).

The numbers indicate responses similar to those of the total sample, with the difference being the larger standard deviation. The results again are similar, with the standard deviation being larger. There is a more prominent difference in the results of the researchers, due to the small number of participants who gave their occupation as 'researcher'.

Table 7.7
Means and Standard deviations of the items in the pre-questionnaire (N=126, Participants via Prolific.ac).

Item	Mean	Standard Deviation
Discuss components of business models.	4.80	1.70
Explain relevance of components of business models.	4.80	1.70
Provide solid interpretation of what business model components are.	4.59	1.73
Describe the components of a business model in my own word	4.68	1.65
Sufficient number of ideas on how to change an existing business model.	4.79	1.66
Creative ideas on changing an existing business model.	4.76	1.75
High quality ideas on how existing business models can be changed.	4.56	1.61
Different ideas on how existing business models can be changed.	4.75	1.66
Make recommendations regarding business model changes	4.70	1.58
Make tradeoffs on what should be changed in a business model.	4.56	1.68
Identify the most effective business model changes. within a set of alternatives.	4.71	1.66

Post-questionnaire results

After finishing the tasks from the scenarios, the participants were asked to complete a post-questionnaire. As we wanted to test the effect of the artifact, we included in the post-questionnaire the same items we included in the pre-questionnaire. However, this time the participants were asked to specifically focus on the artifact they had just used. Also, some items were added focusing on the participants' experience with the whole process, the required mental effort, satisfaction, and personal learning.

Experience with the artifact

Although we aimed to evaluate the effect of the functionalities of the business model about the business model exploration, we cannot claim that the results are entirely based on the functionalities. The results might be affected by intermediate factors. To test for the independent variables, we added relative items in the post-questionnaire. To explore the results, we created frequencies histograms and evaluated the means and the standard deviations for the four items regarding the intermediate variables. The means could range from 1 (= strong disagreement) to 7 (= strong agreement).

In the post-questionnaire, we asked specific questions about the experience with the artifact and the whole experiment. The participants mentioned that the experience with the experiment required moderate mental effort. While the required mental effort was higher than we aimed for especially considering that during most experiments the researcher was not physically present. Figure 7.14 presents the percentages of participants' mental effort and the extent to which the objectives of the experiments were clear.

The participants were relatively satisfied with the whole experiment and their experience with the artifact (μ=4.72, σ=1.848). An even higher percentage of the participants said that after the use of the artifact, they had increased their knowledge regarding business models (μ=5.28, σ=1.574), see Figure 7.15.

Overall, we can argue that the use of the artifact increased the knowledge levels of the participants (personal learning), and they were satisfied with the whole process. We have to mention though that the standard deviation was large.

N=192 (All the participants)

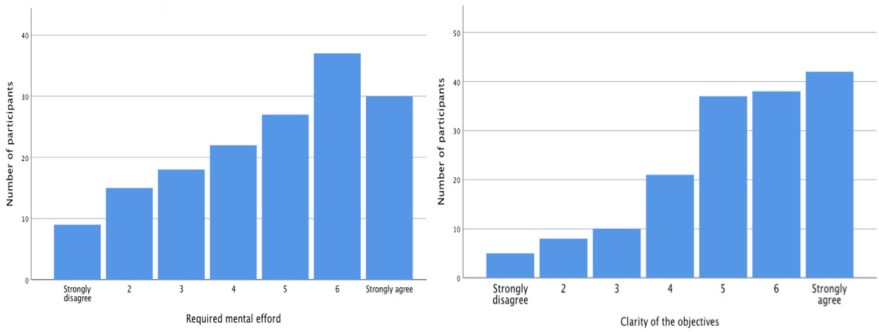

Figure 7.14
Percentages of participants' required mental effort and how clear the objectives of the experiment were.

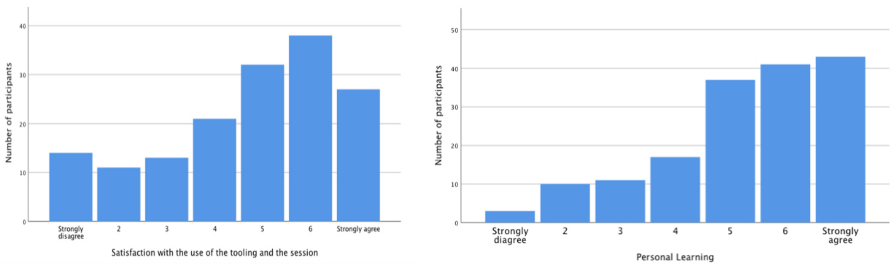

Figure 7.15
Percentages of participants satisfaction, and the personal learning after the use of the artifact.

Table 7.8 presents an overview of the means and standard deviation deviations of the post-questionnaire items for all the participants.

The results show that after they had used the artifact for the specific scenarios, the participants had a moderate to a high level of understanding of the business model components. The participants were less able to explain which components are relevant for specific cases but were still at a high level. The results regarding the description of the components of a business model in their own words were a little higher.

We analyzed the results taking occupation into consideration. For an overview of the spread of the answers for the four items, see igure 7.16. Similar to the answers to the pre-questionnaire, entrepreneurs had a higher level of understanding. Reviewing the results related to occupation, again the entrepreneurs ranked higher, with the researchers coming

Table 7.8
Means, and standard deviations of the items of the post-questionnaire (N=192, All the participants).

Item	Mean	Standard Deviation
Discuss components of business models.	5.26	1.33
Explain relevance of components of business models.	5.05	1.29
Provide solid interpretation of what business model components are.	5.02	1.37
Describe the components of a business model in my own word	5.07	1.40
Sufficient number of ideas on how to change an existing business model.	5.19	1.36
Creative ideas on changing an existing business model.	5.17	1.27
High quality ideas on how existing business models can be changed.	5.01	1.31
Different ideas on how existing business models can be changed.	5.27	1.28
Make recommendations regarding business model changes	5.16	1.27
Make tradeoffs on what should be changed in a business model.	4.86	1.42
Identify the most effective business model changes. within a set of alternatives.	4.86	1.40

second. The other groups had similar results. Similarly, the participants were able to interpret the business model components. The results of the groups are similar, but we have to mention that the standard deviation is quite high and that that should be taken into account.

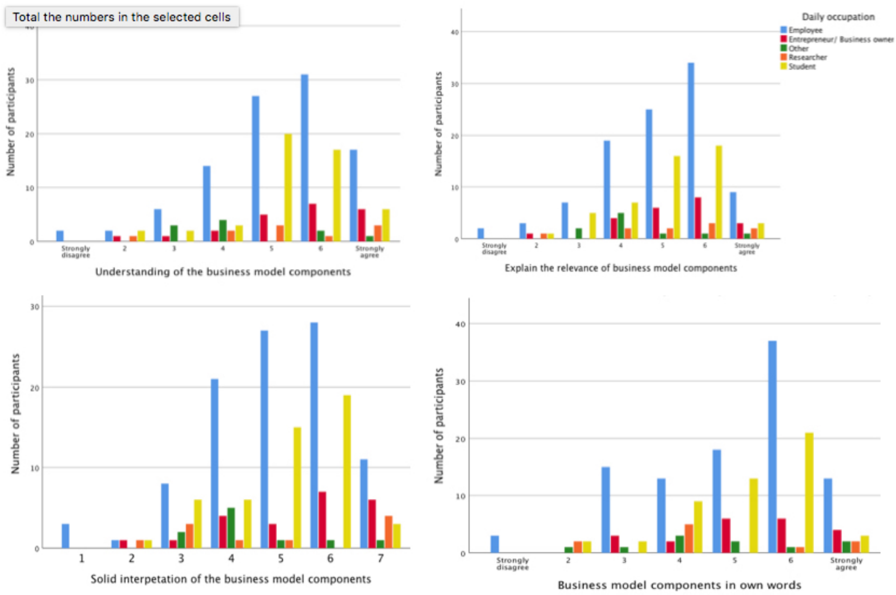

Figure 7.16
The spread of the answers for the four items related to the ' Understanding of the business model component' per daily occupation.

Next, the participants were asked about their ability to generate ideas regarding business model components. Regarding the sufficient number of ideas on how to change existing business models, participants were moderately capable of generating ideas. The participants said that they were less capable of generating high-quality ideas on how existing business models can be changed. The participants also said that they were highly capable of generating different ideas on how existing business models can be changed.

The participants were asked about the extent to which they were able to make decisions about adaptations to business model components after the use of the artifact. The participants were moderate to highly capable of making recommendations regarding business model changes. We analyzed the results taking occupation into consideration. For an overview of the spread of the answers for the four items, see Figure 7.17. Researchers said that they were highly capable of generating ideas. The outcome was similar regarding the generation of creative ideas. Researchers were again ranked higher. Entrepreneurs said that they were highly capable of generating high-quality ideas, while the students were the least capable.

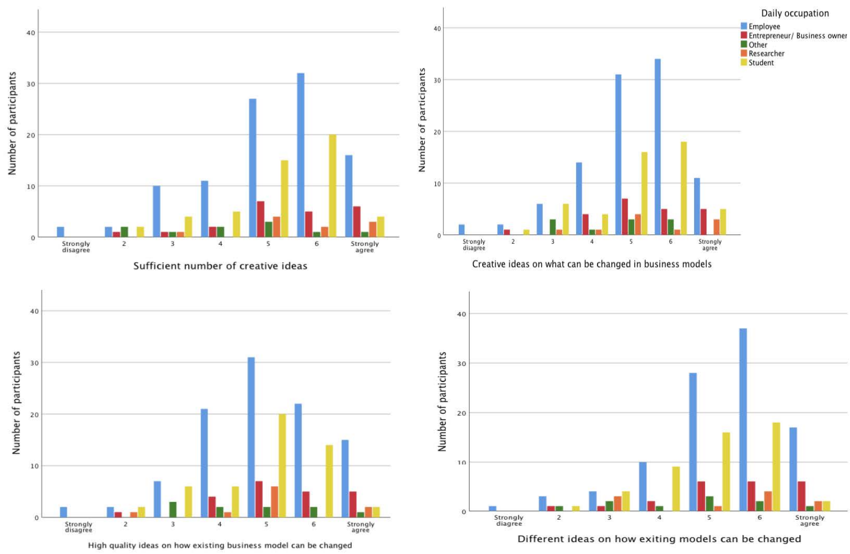

Figure 7.17
The spread of the answers for the four items related to 'idea generation' per daily occupation.

Finally, the participants were asked about the extent to which they were able to make decisions concerning the adaptation of business model components after the use of the artifact. The participants were less positive regarding their ability to make trade-offs on what should be changed in a business model.

We analyzed the results taking occupation into consideration. For an overview of the spread of the answers for the four items, see Figure 7.18. Researchers and entrepreneurs said that they were highly capable of making decision about the adaptation of business model components. The participants were less positive regarding their ability to make trade-offs on what should be changed in a business model. Researchers were more capable of making trade-offs. Similarly, the participants said that they were able to identify the most effective business model changes from a set of alternatives (μ=4.86, σ=1.40). Entrepreneurs were highly capable of identifying the most effective business model changes from a set of alternatives.

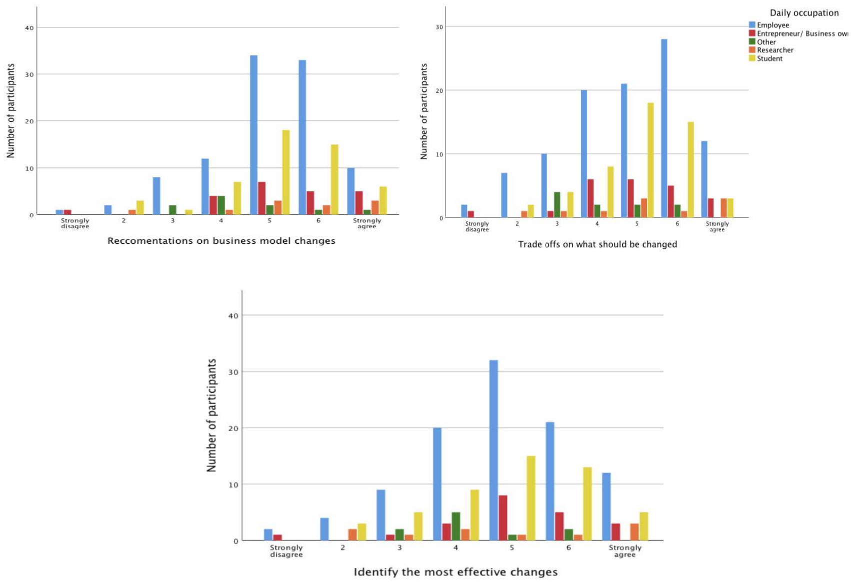

Figure 7.18
The spread of the answers for the four items related to decision making per daily occupation.

The numbers indicate responses similar to those of the total sample, with the difference being the larger standard deviation. As mentioned, this difference is normal because as the sample size increases the variability is expected to increase. The results are again similar, with the standard deviation being larger. There is a more prominent difference concerning the results of the researchers, due to the small number of participants referred to as 'researcher'.

We performed ANOVA test to see if there are significant answers between the different setting and different daily occupations. However, the results did not indicate a significant difference between the different settings and daily occupations.

Pre- and Post-questionnaire results comparison

N=192 (All the participants)

Comparing the means of the items before and after the use of the artifact for the specific scenarios shows that after the use of the artifact, the participants' results were more positive. This suggests that the developed artifact used by the participants in general contributed positively to the dependent variables. Additionally, we can see that the standard deviations after the use of the artifacts are smaller. This shows that there was less variance between the answers of the participants and that a consensus on the opinions exists, see Table 7.9.

Table 7.9

Means, and standard deviations of the items in the pre- and post-questionnaire (N=192, All the participants).

Item	Pre-questionnaire		Post-questionnaire	
	mean	st. deviation	mean	st. deviation
Discuss components of business models.	4.98	1.63	5.26	1.33
Explain relevance of components of business models.	4.93	1.63	5.05	1.29
Provide solid interpretation of what business model components are.	4.83	1.67	5.02	1.37
Describe the components of a business model in my own word	4.85	1.58	5.07	1.399
Sufficient number of ideas on how to change an existing business model.	4.94	1.61	5.19	1.36

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Table 7.9 – continued from the previous page

Item	Pre-questionnaire		Post-questionnaire	
Creative ideas on changing an existing business model.	4.88	1.65	5.17	1.27
High quality Ideas on how existing business models can be changed.	4.77	1.55	5.01	1.30
Different ideas on how existing business models can be changed.	4.88	1.59	5.27	1.28
Make recommendations regarding business model changes	4.80	1.50	5.16	1.27
Make tradeoffs on what should be changed in a business model.	4.74	1.59	4.86	1.42
Identify the most effective business model changes. within a set of alternatives.	4.82	1.59	4.86	1.39

We also investigated the differences between the means of the items in the pre- and those in the post-questionnaire per occupation. We can see that employees were more positive after the use of the artifact. Additionally, the standard deviation is smaller, which shows that the opinions of the employees are to a large extent similar. Similarly, students were to a small extent more positive after the use of the artifact, with the standard deviations being smaller. Entrepreneurs were to a larger extent positive after the use of the artifact and their opinions were less variant. However, researchers ranked some items lower than before the use of the artifact. Other participants were in most cases more positive after the use of the artifact. 7.10.

Table 7.10

Means of the items of the pre- and post-questionnaire per daily occupation (n=192).

Item	Employee		Entrepreneur		Researcher		Student		Other	
Items	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Discuss components of business models.	4.59	5.26	5.67	6.22	5.67	5.17	5.00	5.32	5.00	5.32
Explain relevance of components of business models.	4.62	4.99	5.56	5.78	5.17	5.00	5.09	5.08	5.09	5.08
Provide solid interpretation of what business model components are.	4.39	4.96	5.33	6.22	4.67	4.17	5.09	5.08	5.09	5.08
Describe the components of a business model in my own word	4.61	5.02	5.00	5.78	4.83	3.67	4.87	5.16	4.87	5.16
Sufficient number of ideas on how to change an existing business model.	4.69	5.16	5.78	6.22	4.67	5.67	4.87	5.18	4.87	5.18
Creative ideas on changing an existing business model.	4.62	5.13	5.67	5.89	4.83	5.33	4.96	5.18	4.96	5.18

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Table 7.10 – continued from the previous page

Item	Empl.		Entepr.		Resear.		Stud.		Other	
High quality Ideas on how existing business models can be changed.	4.49	5.01	5.22	5.67	4.17	5.00	4.65	4.88	4.65	4.88
Different ideas on how existing business models can be changed.	4.73	5.41	5.22	5.67	4.00	5.00	4.87	5.04	4.87	5.04
Make recommendations regarding business model changes.	4.54	5.13	5.56	5.89	5.33	5.50	4.74	5.18	4.74	5.18
Make tradeoffs on what should be changed in a business model.	4.39	4.87	5.11	5.56	5.00	4.83	4.83	4.98	4.83	4.98
Identify the most effective business model changes within a set of alternatives.	4.59	4.85	5.33	5.78	5.17	4.50	4.87	4.90	4.87	4.90

N=126 (Participants via Prolific.ac)

We validated the results by focusing explicitly on the results collected via the crowdsourcing platform. Here, we discuss those results.

We can see that the results are similar to those of the total sample, with the difference being the larger standard deviation. As mentioned, this difference is normal because as the sample size increases the variability is expected to increase. In Table 7.11 we provide the means of the items for the participants via Prolific.ac per daily occupation. The results again are similar to a larger standard deviation. This difference is more prominent on the results of the researchers. This is due to the small number of participants referred to their daily occupation as a 'researcher'.

Table 7.11

Means of the items in the pre- and post-questionnaire per daily occupation via Prolific.ac (n=126).

Item	**Empl.**		**Entepr.**		**Resear.**		**Stud.**		**Other**	
Items	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
Discuss components of business models.	4.59	5.26	5.00	6.22	5.67	5.17	5.00	5.13	5.00	4.33
Explain relevance of components of business models.	4.62	4.99	4.67	5.78	5.17	5.00	5.09	5.09	4.67	4.00
Provide solid interpretation of what business model components are.	4.39	4.96	4.00	6.22	4.67	4.17	5.09	5.00	4.00	4.00
Describe the components of a business model in my own word	4.61	5.02	4.00	5.78	4.83	3.67	4.87	5.17	4.00	3.67
Sufficient number of ideas on how to change an existing business model.	4.69	5.16	4.33	6.22	4.67	5.67	4.87	4.96	4.33	3.67
Creative ideas on changing an existing business model.	4.62	5.13	4.33	5.89	4.83	5.33	4.96	5.22	4.33	4.00

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Table 7.11 – continued from the previous page

Item	Empl.		Entepr.		Resear.		Stud.		Other	
High quality Ideas on how existing business models can be changed.	4.49	5.01	4.33	5.67	4.17	5.00	4.65	4.83	4.33	4.33
Different ideas on how existing business models can be changed.	4.73	5.41	4.33	5.67	4.00	5.00	4.87	4.83	4.33	3.33
Make recommendations regarding business model changes	4.54	5.13	5.00	5.89	5.33	5.50	4.74	5.09	5.00	4.00
Make tradeoffs on what should be changed in a business model.	4.39	4.87	4.67	5.56	5.00	4.83	4.83	4.74	4.67	3.67
Identify the most effective business model changes. within a set of alternatives.	4.59	4.85	4.33	5.78	5.17	4.50	4.87	4.78	4.33	3.67

Reviewing the results for the total sample and those for the participants in the Prolific.ac experiment, we can see that the latter ranked the questionnaire items higher after they had used the artifact. In some instances, mainly in the cases of the researchers, some items were ranked lower after the use of the artifact. From the quantitative data, we cannot understand what caused that decline. However, the qualitative data that we discuss in the following section contributes to our understanding of these results.

The purpose of the experiment was to test how the use of the artifact affects the participants' experience with the business model exploration. To do so, we measured their experiences just before and just after the use of the artifact. Previously, we reflected on the differences between the means of the items before and after the use of the artifact. However, to conclude whether and, if so, to what extent the artifact contributes to business model exploration, we need to determine whether the difference between the answers before and after is significantly related to the items. We, therefore, conducted a paired t-test [85].

There was a significant difference between the scores for '*description of business model components*' before and after the use of the artifact. However, there was not a significant difference for the scores for item '*explain the relevance*' pre and post (μ=5.04). That insignificance may be related to the experimental design, whereby the participants followed the tasks for specific scenarios, and they did not have sufficient time to reflect on the relevance of their actions to business model components. The results indicate that the participants were able to provide their own '*interpretation of the business model components*' better after the use of the tooling. As we were testing the pre-filled functionality, we did not purpose a detailed explanation regarding the meanings of the components. Therefore, we can argue that the 'pre-filled' functionality helped the participants to make their own interpretations regarding the business model components. For similar reasons, the results regarding the description of the business model components were probably significantly improved after the use of the artifact.

There was also a significant difference in the scores for the items '*describe the business model components on my own words*', 'sufficient number of new business model ideas', '*creative business model ideas*', '*high quality ideas*', '*different ideas*' pre- and post. It is possible that the participants used the artifact as a brainstorming pool of ideas. That is in align with official and unofficial discussions we had we indicated (and described) the tooling as a brainstorming tool.

There was a significant difference in the scores for the item '*recommendations on the changes on the business model component*' pre (μ=4.80) and '*recommendations on the changes on the business model component*' post (μ=5.15) conditions; t(191)= 2.80, p=0.005. Yet, there was not a significant difference in the scores for item '*trade offs of the potential changes*' pre (μ=4.74) and 'trade offs of the potential changes' post (μ=4.86) conditions; t(191)=0.94, p=0.179, and not a significant difference in the scores for item 'effective changes' pre (μ=4.83) and '*effective changes*' post (μ=4.86) conditions; t(191)= 0.28, p=0.42. The results indicate that the use of the business model tooling did not support the decision-making process. Considering that the assessment questions were extracted from the literature and that the need for assessment is expressed, we can argue that the reasons behind this insignificance are the non-functional requirements, the layout, and the lack of a final recommendation from the tooling. The qualitative feedback might indicate the reasons behind this insignificance. Table 7.12 presents the mean differences, the standard deviation and the t-test results for the whole population.

N=126 (Participants via Prolific.ac)

Again, we wanted to validate the results by focusing on a specific setting, namely Prolific. The results of the statistical power allowed us to focus on this setting only as it is. The results for the Prolific.ac participants are similar to the total participants' sample. Again, the results are similar to those of the total sample. The same item pairs were not significant. Focusing on Prolific, we then wanted to identify whether there were differences in the results between occupations.

Table 7.13 presents the means, standard deviations, and the results from the paired t-tests per occupation.

Table 7.12
T-test results for all the participants(n=192).

DPx	Item	Mean	Std. Deviation	T-test
DP1	Discuss components of business models.	0.26	0.22	t(190)= 1.83, p=0.02
	Explain relevance of components of business models.	0.10	0.22	t(190)= 0.75, p=0.10
	Provide solid interpretation of what business model components are.	0.18	0.22	t(190)= 1.25, p=0.04
	Describe the components of a business model in my own word	0.21	0.21	t(188)= 0.56, p=0.04
DP2	Sufficient number of ideas on how to change an existing business model.	0.25	0.22	t(191)= 1.76, p=0.03
	Creative ideas on changing an existing business model.	0.28	0.22	t(191)= 2.00 p=0.01
	High quality Ideas on how existing business models can be changed.	0.24	0.22	t(191)= 1.72, p=0.03
	Different ideas on how existing business models can be changed.	0.38	0.23	t(191)= 2.70, p=0.01
DP3	Make recommendations regarding business model changes	0.36	0.21	t(191)= 2.80, p=0.01
	Make tradeoffs on what should be changed in a business model.	0.13	0.22	t(191)= 0.94, p=0.18
	Identify the most effective business model changes. within a set of alternatives.	0.04	0.22	t(191)= 0.28, p=0.42

Table 7.13

Paired t-test results for Prolific.ac participants per daily occupation.

Item	Employee		Entrepreneur		Researcher		Student		Other	
	Mean	t-test results	Mean	t-test results	Mean	t-test results	Mean	t-test results	Mean	t-test results
Discuss components of business models.	0.67	t(84)=3.3, p=0.00	0.5	t(8)=1.1, p=0.3	0,67	t(5)=0.89, p=0.41	0.13	t(22)=-0.28, p=0.78	0.67	t(2)=-0.55, p=.63
Explain relevance of components of business models.	0.36	t(84)=1.89, p=0.06	0.16	t(8)=0.39, p=0.71	0.67	t(5)=0.3, p=0.77	0,09	t(22)=0.00, p=1	0.67	t(2)=1, p=.42
Provide solid interpretation of what business model components are.	0.58	t(84)=2.80, p=0.00	0.5	t(8)=1.5, p=0.15	0,	t(5)=0.54, p=0.61	0.30	t(22)=0.2, p=.84	0	t(2)=0, p=1

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Table 7.13 – continued from the previous page

Item	Employee		Entrepreneur		Researcher		Student		Other	
Describe the components of a business model in my own word	0.41	t(84)= 2.00, p=0.05	1.17	t(8)= 1.67 p=0.13	0.33	t(5)=2.44, p=0.06	0.09	t(22)=- 0.78, p=.44	0.33	t(2)=- 0.20, p=0.87
Sufficient number of ideas on how to change an existing business model.	0.47	t(84)= 2.30, p=0.02	1.00	t(8)= 0.69, p=0.51	0.67	t(5)=- 1.58, p=0.17	- 0.26	t(22)=- 0.20, p=0.84	0.67	t(2)=- 0.29, p=0.8
Creative ideas on changing an existing business model.	0.51	t(84)= 2.55, p=0.01	-0.5	t(8)= 0.3, p=0.77	0.33	t(5)=- 0.7, p=0.52	- 0.174	t(22)=- 0.56, p=0.58	0.33	t(2)=- 0.30, p=0.8
High quality Ideas on how existing business models can be changed.	0.518	t(84)= 2.68, p=0.01	-0.83	t(8)= 0.71, p=0.5	0	t(5)=- 1.18, p=0.29	0.04	t(22)=- 0.4, p=0.69	0	t(2)=- 0.00, p=1

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Table 7.13 – continued from the previous page

Item	Employee		Entrepreneur		Researcher		Student		Other	
Different ideas on how existing business models can be changed.	0.69	t(84)= 3.27, p=0.00	-1	t(8)= 0.71, p=0.5	1	t(5)=- 1.37, p=0.23	- 0.35	t(22)=0.1, p=0.92	1	(2)=- 0.65, p=0.58
Make recommendations regarding business model changes	0.59	t(84)= 3.08, p=0.00	-0.17	t(8)= 0.6, p=0.56	1	t(5)=- 0.27, p=0.79	0.09	t(22)=- 0.95, p=0.35	1	t(2)=1.00, p=0.42
Make tradeoffs on what should be changed in a business model.	0.48	t(84)= 2.46, p=0.01	0.17	t(8)= 0.71, p=0.5	1	t(5)=0.18, p=0.86	0.09	t(22)=0.23, p=0.82	1	t(2)=- 0.73, p=0.22
Identify the most effective business model changes. within a set of alternatives.	0.26	t(84)= 1.36, p=0.18	0.67	t(8)= 0.8, p=0.45	0.67	t(5)=0.75, p=0.48	0.22	t(22)=0.24, p=0.81	0.67	t(2)=- 0.45, p=0.69

7.6 Qualitative feedback

In addition to the quantitative data, we also collect some qualitative feedback by including an open question in the post-questionnaire asking participants to add their comments and feedback regarding the business model tooling. The majority of the participants provided their opinions and some feedback. Some of the comments were short and clear ('*the tool was good*') while other participants provided detailed comments such as '*I think this tool should be customized to different target groups depending on their prior knowledge about business models. [. . .] they can use the tool as a guideline when making decisions for the future business and can also learn at the same time [. . .]. It would also be a great addition if upon completion, the tool can generate a customized nicely designed printable business model. [. . .]. For SME's [Small and Medium Enterprises] or starting businesses students of the relevant field could be recruited to help and practice on real life examples for a small fee*'. The participants were satisfied with the tooling, and they acknowledged its usefulness of the tooling. However, a large portion of the participants said that the tooling was not sufficiently user-friendly. For instance, one participant said that the tooling was 'quite interesting but could be more *user-friendly*'. Participants said that the layout should be improved and that the choice of words could be less challenging. Other comments were related to the size of the checkboxes, the need for manual input, colors, and other characteristics that could improve the user–machine interaction.

The participants said that an issue with the tooling was the choice of a spreadsheet to develop the tooling. They said that the spreadsheet was difficult to use. Some said that the spreadsheet was challenging and in some cases even overwhelming. For instance, one participant said that '*some of the tasks were overwhelming in the sense that I was unsure of how to proceed and that I felt as though if I made an error, I would disrupt the overall function of the program*'. Another participant said that '*the use of the Excel file is good for the person doing the research but it's a strong pain point for the user. Yes it provides more information to you but the format is a problem- sentences inside cells aren't functioning correctly)*'. This participant and several others suggested that the tool needs a different format and, more specifically, that the tooling could be an online tool or a mobile app.

Another frequent comment we received often was related to the last task of the scenario and the relative step of the tooling. Participants said that, while the tooling was a good idea, it required some knowledge about business models. They said that the final task was difficult to do either due to technical issues '*the dropdown menu doesn't work*' or it was '*mentally difficult to fill it*'. The issues and challenges that the participants faced might be why the results regarding the third design principle were not significant. We believe that our choices regarding the non-functional requirements might have affected the effects of the assessment elements on the decision-making. On the positive side, the participants mentioned that the tooling was '*simple to follow and a good learning exercise*'. Other participants said that the tooling was simple and straightforward: '*I don't have much experience with business models, as I am just starting with my startup, but I found this tool really helpful and really easy to use*', participants said that they would recommend the tool and would use it at a real life setting. Finally, participants said that the tooling was useful for their learning process (something to be addressed in the future).

7.7 Chapter Conclusions

This chapter addressed the fifth and last research question of our study, namely '*What are the effects of the developed tooling on the business model exploration process as identified in theory and practice?*' We adopted an experimental design approach, which we presented in detail. We used a pre- and a post-questionnaire, and we created a task-based scenario for the participants to follow. We recruited participants via a crowdsourcing platform (Prolific.ac), via an online learning platform (EdX.org), and from a university (Delft University of Technology). We analyzed the data to evaluate the effect of the developed tooling on the business model exploration. Our findings indicated that the use of the tooling had a positive influence on the understanding of the business model components. The results also indicated that the use of the tooling had a strong influence on the user's idea generation regarding changes in the business model exploration. However, the results did not show a significant effect regarding the decision making on what components can be changed. Additionally, we collected qualitative feedback indicating that the used layout used was not suitable and that a different one would increase the contribution of the functional requirements.

As with every experimental design, our design has its limitations. We identified the limitations and we tried to reduce their affect on the whole process as much as possible.

The first limitation is the absence of a control treatment. While having at least one controlled condition is recommended, we did not have one in our experimental design, as no artifact was available that could have been used as a control condition. We wanted to test how the designed artifact contributes to business model exploration, and existing artifacts are not designed for that purpose.

Another limitation is the use of laboratory experiments. It is argued that laboratory experiments are more distant from the real-world environment than field experiments [132]. However, we chose to do laboratory experiments for the following reasons: (a) The lab setting gave us a higher degree of control over the potential use of the artifact and reduced the confounding factors [165], (b) doing the experiments in a field setting would have entailed the risk of not achieving the sample size estimated from the statistical power; and (c) the participants used the artifact following specific scenarios, making the setting more homogeneous.

The principal researcher was responsible for designing the experiment, setting up the experiments, evaluating the design, recruiting the participants, and finally to conduct the experiment. However, it is recommended that during the experimental design at least one other researcher who is not involved in the research should perform the experiments to avoid informant bias (the human subjectivity when involved in design of an experiment) [232] . In our case the same researcher designed and performed the experiments (and later analyzed the data). However, to avoid the informant bias, the whole experiment was discussed with other researchers involved to some extent in the experimental design, and with external researchers (giving their recommendations on the design). Additionally, when applicable facilitators were responsible for performing the experiments.

Regarding the Design principles:

DP1: Pre-filled business model templates, facilitate the users' understanding of the components of the current business model. From our results we can infer that the pre-filled template was significantly useful for the users to understand the business model components. However, we should mention that the interaction with the other two steps of the tool could also affect the understanding of the business model components.

While 'explaining the relevance of the business model components' did not show a significant difference between pre- and post-usage, overall results indicated that the tooling supported the users' understanding.

DP2: Templates with solution-based patterns improved idea- generation on how to change different components of the current business model. The results indicated that the use of solution-based patterns (during the second step of the tooling) had a positive influence on the idea generation process regarding what can be changed in the business model exploration process. The solution-based patterns were not previously used and from our findings we can say that tooling with this functionality could be used for idea generation processes, brainstorming, and business model exploration.

DP3: Assessment features, improve users' decision making about whether to adapt components in the business model. Our results do not indicate a significant positive improvement. Therefore, we cannot say that the assessment features, as business model functionality, support decision making during business model exploration. However, from the qualitative feedback, it was clear that the layout of the tooling, and the way we implemented the non-functional requirements might have hindered this functionality. We argue that this affected the outcome significantly.

The quantitative and mainly the qualitative feedback indicated suggestions for improvement in the evaluation design and at the tooling that should be taken into consideration in future implementation.

Chapter 8

Conclusions

8.1 Chapter Introduction

In this chapter, we provide our main findings, discuss our contributions to the literature and the practice, present the limitations of the research, and conclude by reflecting on the study and making recommendations for future research.

8.2 Findings

The findings presented in this thesis support the objective of the underlying research, that is, to design tooling to support business model exploration. We did so by answering specific research questions.

The first sub-question was *'What can we learn from exploring the existing business model tooling?'* We presented the answer to this sub-question in 3. Answering it helped us to understand the needed theory. Following a literature review, we defined business models as a cognitive tool that explain the business logic. We see BMI as a process whereby innovations enable changes in business models. We defined the business model exploration concept as the iterative process through which new business model ideas are created, conceptualized, and tested until a revised, alternate, and assumedly viable business model is achieved. Our findings from two exploratory case studies indicated that organizations explore their business models (when opportunities require such), but they are not always aware of how they can do it. Finally, we explored the existing business model tooling and found that the tools are not designed for business model exploration. We identified specific functionalities that existing business model tools have as well as functionalities that are still missing, namely element-level business models, predefined suggestions, and domain-specific.

The next part of our research, (chapter 4) did not provide an answer to a research question, but had an instrumental purpose to understand what new services impact business models in the automotive industry, and what the role of technology is and answer the instrumental question 'what is a suitable domain to develop such tooling for, and most likely to need business models exploration?'. We use Q-methodology as our research approach. Our results indicated that business model studies within the automotive industry should take into account the enhanced personalization of user experience and mobility as a service (MaaS). Our findings show that personalization represents a shift in the automotive industry from a focus on high-volume customizable products, toward individually tailored user experiences. We also found that technologies are not as explicit but are still clearly related to services, as enhanced, personalized user experience and shared mobility are both enabled by technology; these findings indicated the different levels in which technologies become manifest. The IoT was the technology clearly distinguished from others mentioned that could affect business models.

The second sub-question was *'What activities are undertaken during business model exploration?'* (RQ2) We answered this question in Chapter 5, having followed the action research method. We found that the business model exploration process includes:

- evaluating whether technologies influence the 'current' business model, and if so, which technologies do so and how.
- Using different business model tools (or specific functionalities) to create new business models.
- Creating alternative business models, and considering new elements that might be needed and whether technology will require new components/elements.
- Using tools to illustrate alternative options.
- Reflecting on them, discussing with other partners or stakeholders, and making revisions.
- Making decisions on which alternative options will be used, implementing the decisions, trialing them, and implementing something different.

With the same method and in the same chapter, we answered the third sub-question: *'What are the design requirements for designing tooling that supports the business model exploration activities?'*. We found three functionalities for the design of business model exploration tooling. This tooling should be designed based on three recommendations, namely:

- Business model tooling should support the design of business models even when the building blocks are not clearly defined.

- Business model tooling should take into consideration the ability to create alternative business models when new opportunities arise.
- Business model tooling should have functions that support the decision-making regarding alterations to the business model.

According to our results, these recommendations can be used for the design of business model exploration tooling.

The fourth sub-question was: *'What functionalities can support business model exploration?'* We presented the answer in Chapter 6. We used existing (and evaluated) business model ontologies to create an artifact based on the three design principles we previously identified. Contrary to the common approach of analyzing business models at the component (or patterns) level of detail, we decided to go a step further and focus on the element level of detail. To do so, we performed a network analysis to create a list of elements that could support the three design principles. Our research produced a detailed list of elements that can be used to describe business model components. From these processes, we created not only an artifact based on the three design principles, but also a repository of elements that can be used for generic business model tools and ontologies and IoT business model tools and ontologies.

The fifth sub-question was *'What are the effects of the developed tooling on the business model exploration process as identified in theory and practice?'*. We presented the answer to this sub-question in Chapter 7, having followed the experimental design method. Our findings indicated that the pre-filled options of the tooling positively influenced the users' understanding of the business model components, while solution-based patterns have a stronger positive influence on the users' idea generation regarding changes to the business model exploration. Finally, the results did not show a significant effect regarding the decision making on what components can be changed. However, the results indicate a lack of usability regarding the third function of the tool, which may explain why we found no significant effects. The students were satisfied and said that by using the tool they had increased their knowledge of business models. Learners (i.e., students) who participated in the experiments in the offline setting were significantly more positive regarding the business model tooling. The results of the online course indicated that the lack of usability made the tooling less interesting and that it might affect their experience with the tool. Reflecting on the different settings, our study is one of the first to use multiple online and offline settings, and included a crowdsourcing platform to collect data. We lacked the control of who the participants were and we were not able to observe what they did during the experiment, but the time spend on the experiment, the real-time interaction, and their qualitative comments indicate that crowdsourcing platforms can be used for research purposes.

Overall, our findings are useful for academics designing tools for different business model phases. Especially, our study is the first that focuses on providing specific functionalities of tools for the business model exploration phase. Our findings confirm our assumption that a pre-field template facilitates the understanding of the business model components, and the solution-based pattern improves the idea generation regarding changes in the business models. The study did not confirm our assumption that assessment features do not improve the users' decision making on whether to adopt the business model components. Future researchers can use the results of our study to further identify functionalities for tools for business models exploration. Additionally, researchers can use our study as a methodological approach for designing business model tools for other BMI phases. Our study indicates that when designing business models tools, attention to the non-functional requirements should be paid equally to the functional requirements. Finally, our findings indicate that academics and practitioners should stop using empty templates (such as empty Business Model Canvas), as these emplty templates can be replaced with pre-filled templates with predefined answers.

8.3 Contributions

8.3.1 Contribution to IS theory

Previous research has discussed the development of business model tools ([113], [179]), but not specific for business model exploration. Business model exploration requires different tools because, as we discovered via action research (Chapter 5), it is not known exactly what should be done, when, and by whom. Besides, we tested existing business model tooling in practice, and while the tools were useful they insufficiently addressed the business model exploration. We followed this approach as we conducted scientific research toward the design of a not yet existing artifact in 'nature' [216]. During the design, development and evalution of the specific artifact, we developed a theory for design and action [110].

Additionally, we tested existing business model tooling in practice and while they were not useful in the process they were insufficiently addressing the business model exploration. Therefore, this project is a first to develop business model exploration specific tool and to show its impact through an experiment.

8.3.2 Contibutions to IS community

Our study contributes to *the emerging scientific debate in the IS community about the development of a digital tool for businesses to adapt their business models in response to technological challenges.* Based on the IS theory of Gregor and Jones [110], our study contributes to IS theory as we discuss below:

- **Purpose and scope of the theory**: Our design theory is specifically focused on the business model exploration process within a specific domain (i.e., automotive industry) and for a specific exploration enabler (i.e., IoT). The automotive industry was selected so that we could focus our research and understand how IoT affects the business models of a large industry. We aimed to describe the concept of business model exploration and the activities that are undertaken and to create a business model tool that supports the business model exploration.

- **Constructs**: This component focuses on the entities of interest in the relevant theory. The constructs in the design theory are business models, business model innovation, business model exploration, business model tooling, and business model elements. Regarding business models and BMI, we adopted existing definitions from the literature. We defined business model exploration as the iterative process through which new business model ideas are created, conceptualized, and tested until a revised, alternate, and assumedly viable business model is achieved. We focused on the business models tooling as a structured method and guidance for BMI. We discussed the business model tooling functionalities and we identified the commonly used ones such as '*patterns*', '*fill-the-blank*', and '*evaluation*'. We also identified functionalities that were not sufficiently addressed such as '*element level business models*', '*pre-defined suffusions*', and '*domain specific*'.

- **Principles of form and function**: The business model exploration tooling was created based on the non-functional requirements, business model elements, and the identified three design principles.

- **Artifact mutability**:We designed the business model exploration tooling via a three-step approach. Each step can be seen as a separate sub-tool that could add value to the business model exploration process. Our results also indicate which functionalities have a positive impact on the business model exploration process. These individuals or combined functionalities could be used and further extended to develop business model tools that will result in new knowledge regarding the use of business model tooling.

- **Testable propositions**: As part of our research we identified and developed three propositions (i.e., design principles):
  Pre-filled business model templates facilitate the users' understanding of the components of the current business model *(DP1)*.
  Templates with solution-based patterns improve idea-generation on how to change different components of the current business model *(DP2)*.
  Assessment features improve users' decision making about whether to adapt components in the business model *(DP3)*.
  During our evaluation, we found that these propositions (in the form of functionalities) can contribute to the business model exploration process. With our study, we showed that these three principles can be combined and support the business model exploration

- **Justificatory knowledge**: Different theories were adopted and translated into design knowledge to develop and evaluate the artifact. Justificatory knowledge was used regarding the business model exploration process, opportunities as enablers, and the business model functionalities as a basis for the development of design principles. More specifically, the business model innovation theory indicated the activities to be undertaken during business model exploration. Opportunity theory was the basis for defining technology as an opportunity that enables business model change.

- **Principles of implementation**: The lessons learned from our action research study are:(a) Pre-filled components can contribute to the understanding of the business model components, (b) solution-based business model components can support the idea generation, (c) the design requirements need to be extracted with empirical research, and (d) the need for assessment criteria is important but at the same time the usability of the tooling needs to be appropriate.

- **Expository instantiation**: The last component of the IS theory construction is the physical implementation in the form of an expository and testing artifact. As part of our research a working prototype was designed (Chapter 5) developed (Chapter 6), and evaluated (Chapter 7).

8.3.3 Contributions to the business model literature

Our study is one of the first to specifically focus on the *business model exploration*. Previous studies focused on different aspects of BMI such as the concept of BMI, such as the concept of trial and error [203] or the generation of new ideas ([20], [161]), More specifically assessed what could happen under a range of different decision choices and alternatives [117]. Our study conceptualized the above under the term of business model exploration. It is also one of the first to investigate the process of exploring business models from an old to a revised business model. We defined the concept of business model exploration and identified the activities undertaken during the process. We observed the process through empirical research (Chapter 5) and identified issues with the exploration, main challenges, and questions that arise.

Our study contributes with the set of the design principles implemented as business model tooling functionalities. Prior studies developed business model tools. More recent studies were interested in creating frameworks for the design of business model tools by testing different formats of business model tools in practice [78]. Our study is one of the first to design business model tooling for business model exploration, by focusing on identifying specific functionalities. Our study provides insights into functionalities that can support the business model exploration. We found that business model exploration requires functionalities that were not commonly used previously, such us *pre-filled options* and *domain specific business model components*. While we were not able to make comparisons due to the lack of a control treatment in the experiment, our results show that tools that provide potential answers can support the exploration of suitable business models, and that designers should consider that option in addition to the already widely used fill-in-the-blank approaches (e.g., the Business Model Canvas ontology).

Our study contributes to the business model tooling literature with our *evaluation approach*, which can be used as a guideline to test various business model tooling functionalities. More specifically, the experimental design can be used for alternative business model tooling or business model tooling functionalities. We created the experimental design in such a way that it can be used for different functionalities as long as technology plays an important role. Our experimental design could also be adapted such that alternative functionalities can be tested so that it can be decided upon what functionality is preferred for specific activities.

Finally, related to the *business model elements*, our study is the first to review IoT business model literature and based on this review to identify business model elements related to IoT. Our study sees IoT as an important part of the business model design that requires changes in the traditional business model ontologies. Studies can use these elements to revise business model ontologies taking into consideration the IoT technology. Our research approach towards the IoT business model elements can be used for other technologies that fundamentally change the business models. This study adds to the discussion of *business model tooling for IoT*. For instance, [49] focused on the value creatied by the IoT directed toward the long-term goals of the organization, while [187] discussed the importance and the transformative potential of the IoT, and presented prospective business models. Westerlund et al. proposed four key pillars of a business model design tool for IoT ecosystems. Additionally, [230]. Dijkman et al. [73] [74] used the Business Model Canvas to identify the building blocks that are relevant to the IoT as well as their importance (idem). Our study went into more detailed by focusing on the 'elements level' of detail and not investigating the building blocks.

8.4 Implications for practitioners

Below, we discuss our contributions to the practitioners, such as business model designers, entrepreneurs, managers or consultants.

Overall, our business model tool provides a break from practice as it focuses on *business model exploration*. Also, the business model tool goes beyond the 'typical' brainstorming session as it provides a set of options. Our tool has the potential to obviate the need for domain experts and consultants, as it allows one to do own business model exploration.

We contribute to practice in the form of the business model tooling developed based on the *design principles*. In our study, we used and tested in practice, existing business model tools toward the exploration and design of business models in a setting where products are developed for no yet existent markets. Our recommendations can be used as requirements for business model designers for the development of business model tools. The ways we designed and developed of the business model tooling could be used as a guideline for business model tooling designers to design, develop, and evaluation technology-enabled business models. Our research can contribute to the practice and can be valuable for different actors within the practice. Designers can use these as prescriptions to design and develop relevant business model tools. Regarding the evaluation description, practitioners can use our detailed experimental design to test the effectiveness of newly designed business model tools.

The results of the *Q-methodology* study have implications for the practitioners within the automotive industry and/or business model consultants. We contribute to the automotive industry by providing concrete insights into how technology-enabled new services impact business models in the automotive industry. This study explored what types of technology-enabled services have the most significant impact on current business models within the automotive industry. The perspectives we identified show the relevance of servitization, service bundling and auxiliary services in understanding how business models in the automotive industry will change. They also illustrated how experts have different perspectives on the abstraction level of technology-induced business model change. Our findings will help to inform practitioners such as consultants and strategists focusing on the future of the business model within the automotive industry. Lastly, our study contributes to the development of business model tooling for business model innovation in the automotive industry and provides roadmaps to realize business models.

Finally, the use of the tooling in a practical setting has the potential to enrich the BMI activities such us exploration, design, and implementation in a brainstorming setting in which the tooling is used. Similarly, our tool could be used in learning environments to enhance the pedagogical tools for teaching business models. More specifically, the artifact requires no previous experience, because it provides domain knowledge (a lack of which often prevents people from trying out tools) that has a positive impact on understanding business models. Our approach can be used by the practitioners for the development of business model tools in other domains (apart from the automotive industry).

8.5 Limitations

Our study has a high internal validity but a lower external validity. While the generalizability of our study is limited, it does allow replicability (i.e., the transferability of the design and methods) to other technologies and domains. More specifically, the limitations discussed here are related to the functionalities we used and the ones we did not use, the generalization of our results from the specific cases, the evaluation approach, and finally the interpretation of the results.

Another limitation we need to mention is the *lack of a control treatment for the experimental design.* It is common in experimental designs, for participants to be assigned to more than one treatment. This treatment had to be as similar as possible to our developed tooling in non-functional requirements (i.e., online tool, no prior knowledge needed, etc.) and as dissimilar as possible to the functional requirements. Our first idea was to use as a control treatment an online version of the Business Model Canvas tool. The Business Model Canvas does not have the same functionalities as the ones we wanted to test with the treatment condition and has similar non-functional requirements. However, assessing the identified changes with the business model Canvas tool is not possible. While the Canvas can serve as a starting point for more discussions towards what can be done or changes in the business model, the tool itself does not provide the possibility to assess the identified changes. However, it is not possible to assess the identified changes with the Business Model Canvas tool. While the Business Model Canvas can serve as a starting point for more discussions toward what can be done or what changes can be made to the business model, the tool itself does not provide the possibility to assess the identified changes. However, it is important to note that the Business Model Canvas tool does not promise that thw assessment of the changes is a characteristic of the tool. Therefore, we argue that we could not use the Business Model Canvas (or other existing tools). That is an important limitation, as we cannot draw conclusions if our functionalities are preferred over alternative functionalities. What we can say is that these functionalities have a positive effect on business model exploration. Future research could use the same experimental design with alternate tools and draw conclusions by comparing different functionalities.

We indicated that the *use of the Microsoft Excel program* was not appropriate for the development of the tooling. An alternative, suggested by the participants, would be to develop a website. Indeed, a website could improve both the usability (i.e., the efficiency and effectiveness of the tool, and the satisfaction of the participants) [87] and the user experience (i.e., the user's experience when interacting with the product). This is relevant since the lack of usability prevents the establishment of the effects of an artifact's functionalities. Still, the participants were significantly more positive after using our developed tooling. In the future, a website could be developed and then evaluated.

There are also limitations related to the use of *experimental design for evaluation purposes*. We used a controlled setting (i.e., the experimental setting) rather than the commonly used method of case studies. Evaluating the designed tooling with a case study method could provide us with data from a more realistic setting, and data from different periods. Additionally, using a case study method, we could observe how the tooling was used at different times and in different situations. An argument that can be made in favor of experimental design, is that it increases the internal validity, due to the higher degree of control. Besides, our approach supported the external validity as we collected data from different people, and we replicated our experimental design in three different settings and with different –participants and found largely similar patterns.

There are limitations related to the design principles, which were based on *a single action research project*. Collecting data from a single case might threaten the external validity and therefore the generalizability of the results. Investigating multiple cases could allow a comparison of the findings and the drawing of more firm conclusions regarding the design principles. However, because we wanted to actively intervene in the case study, it was not possible to participate in multiple cases. Also, our focus was on designing and evaluating tooling. If we had done four or more case studies, we would not have had sufficient time to evaluate and do the experiments. However, we took specific actions to increase the validity of our results. We communicated with and received feedback from the project partners after each activity (e.g., by giving presentations, and holding virtual and face-to-face meetings), and our activities, results, and data were discussed with informants both within and outside the project. Future studies could investigate to what extent these design principles are suitable for other cases. Furthermore, our experiments via EdX.org indicate that the participants were able to use the artifact for different cases and in different settings, as they were given the option to use the artifact for their businesses (after participating in the scenario-based experiment). While this case allowed us to further understand business model exploration and to identify the three design principles, studies could evaluate to what extent our results apply to other cases.

Another limitation of our study is the *focus on a single industry as a domain*. Using a specific domain might trigger concerns about the generalizability of our results. Another approach could be to investigate additional domains such as healthcare or finance. By doing so we could increase the external validity of the study. For instance, we could focus on the healthcare industry, which is one of the largest industries and a huge number of enterprises in the sector are affected by technologies. It is an industry where the privacy, security, and governance of sensitive data requires additional activities and restrictions that could lead to reduced external validity. However, because of our time restrictions and our interest in designing domain-specific tooling, we decided to focus on a specific domain. It would be interesting to see whether our approach in different domains would result in the same effects and, if so, how. Such studies could test the generalizability of our design principles and could investigate how different domains and technologies can influence the results and design choices.

The final limitations are related to the involvement and complexity of the stakeholders. It is important to mention that we did not take into consideration the stakeholders involvement and complexity. We are aware that business model exploration takes place in settings with multiple stakeholders, which have not only conflicting interests and values but also different worldviews. While we considered this in the action research study, in the experimental setup we chose to limit the complexity of the socially situated context in which business model exploration takes place. Additionally, we did not take into account the moral implications that new technologies trigger, as we did not discuss values related to responsible design. More specifically, in our design, we neither included the values of safety, security, and privacy, nor the values related to smart technologies. Future research can test these concepts in a realistic setting where stakeholders add to the complexity. Focusing on the stakeholders' complexity can provide additional findings contributing to both academia and practice. It can be valuable to examine if the results of the studies at a realistic setting confirm our results and their additional contributions.

8.6 Recommendations for future research

Societal complexities are transforming how we perceive and use digital technologies. Digital technologies can be seen as enablers of innovation that enhances various aspects of human life. Increasingly, technologies technologies can be seen as enablers of innovation that enhances various aspects of human life. Technologies provide major opportunities for industries, developers, designers, policymakers, managers and strategist to create capture and deliver added value. However, in addition to the opportunities, technologies also pose hazards for the involved stakeholders due to the systems and network complexities, customers' involvement, and the intertwined relations within and outside the organizations.

Our results from the action research (Chapter 5) indicate that agile approaches could be a valuable method for BMI within an opportunity based innovation project, where people (or teams) collaborating in an iterative process towards a common aim related to BMI, especially within complex networks of people. The role of agility as a method supportive of business model exploration is still under-discussed. Agility is the idea of applying existing knowledge while also learning from current experience, being flexible, and responding quickly to change to develop high-quality outcomes (within a short period) [100]. Agility '*aligns development efforts with business values by making people from both business and design work together*' [41] An agile approach involves iterative planning and feedback to teams that continuously adapt to the needs and requests of and feedback from other collaborators and customers. Also, an agile approach is open to the changing requirements of customers and allows iterative development cycles and co-design with customers. Furthermore, the agile approach is relevant for innovation projects in which people (from different backgrounds) collaborate to achieve an innovative outcome.

Business model tools can serve as boundary objects to structure the process of BMI as they can be adapted to the needs of the different constraints of the involved parties over time. As found in the literature '*tools are expected to facilitate the process of developing new business models together with a company's stakeholders by reducing transaction costs and improving organizational routines when coordinating different development activities*' ([78] p.520). As discussed in this thesis, tools can provide a supportive tool for BMI. In our study, we developed a tool for a specific BMI activity (i.e., the business model exploration) and a specific technology. However, IT solutions are needed throughout the business model life-cycle [210]. Focusing on the interplay of business models, technology, product design, and development and management would be valuable for future research. More specific:

(1) *the business model ontological uncertainty.* Since technology can be seen and used in unforeseeable ways, effective business model ontologies are principally unknowable. Doing more research on business model exploration and the tools that can be used (and how they can be used) will provide insights into which business model ontologies are effective, when they are effective, and what should be changed (or adapted) to fit the opportunities that arise **(2)** *The agility*: As mentioned, agility has only recently been discussed in relation to business models. Additionally, how business consultants, business model designers, product designer and developers, and managers interact is less discussed especially from the perspective of the designers and developers. Our action design case illustrates how the agility is happening in practice, but additional research is needed, especially focusing on how the multi-stakeholders' complexity could be solved using agile approaches. **(3)** *The customer's involvement*: For our research, we did not take into account how customers can affect the requirements for the design of business model exploration. Taking into account the requirements of the customers could lead to different business model ontologies with different components. **(4)** *The identification of the external stimuli for innovation*: In this research, we focused on the technology as a stimulus for business model innovation. However, additional external factors could influence the design of new business models and **(5)** *The development of business model tooling that takes into account the previous points*: This is related to how the previous points could reflect on the design of business model tools. While we identified some functionalities that could be used for the design of business model tools, how the above points could affect the development of business model tooling is unknown.

To summarize, future research could follow a holistic approach and investigate BMIs, business model innovation, collaborative design, and consumer behavior in the context of an increasingly complex entrepreneur ecosystem. Such research could focus on the business models from the applied context of service (or product) development perspective (e.g., organization, consumer research, marketing research) and technology influence. In this future research, agility will be the main focus, taking into account the design teams, the product developers, how future products or services to be developed fit the organization's business identity, and what the digital tools are that could support this agile approach and at the same time how the business identity affects the design of products. This research can be interesting for researching in the field of business models, ICTs, and, industrial engineering.

Final note to academics and scientists:
'Pass on what you have learned.'
–Jedi Master Yoda

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Appendixes

Pre-questionnaire

Dear Participant,
We're very interested to learn how our business model tool, Omega, helps you to learn about business model innovation. Your input is important for improving the tool. Therefore, we'd like you fill out a short questionnaire that will take no more than 4 minutes. Your input will be used for academic research purposes, and data will not be shared. All data is anonymized and analyzed on an aggregated level!

Thank you!!

Alexia Athanasopoulou, MEng, MSc.
PhD Candidate
Delft University of Technology, Delft, The Netherlands

*Required

1. **Do you agree to participate in our research?** *
   Mark only one oval.
   - Yes
   - No

2. **Please add your Prolific ID.** *

   ____

3. **Which role(s) describe your main daily occupation best?** *
   Mark only one oval.
   - Student
   - Entrepreneur/ Business owner
   - Researcher
   - Employee
   - Other: ______________________

To which extent are you familiar with …

4. **…business models innovation (i.e. 'the changes in the business logic for creating and capturing value'?** *
   Mark only one oval.

	1	2	3	4	5	6	7	
Totally unfamiliar	○	○	○	○	○	○	○	Absolutely familiar

5. **…business model frameworks (e.g. CANVAS)?** *
Mark only one oval.

	1	2	3	4	5	6	7	
Totally unfamiliar	◯	◯	◯	◯	◯	◯	◯	Absolutely familiar

6. **…practical tools (e.g. printout of CANVAS) that support business model innovation?** *
Mark only one oval.

	1	2	3	4	5	6	7	
Totally unfamiliar	◯	◯	◯	◯	◯	◯	◯	Absolutely familiar

Business model tools (Business Model tools are anything that helps to visualize a new business model idea. Please indicate if you agree to the following statements.)

Business model tools helps me to...'

7. **…improve my understanding about business models.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

8. **… generate ideas on what I can change in a business model.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

9. **...make decisions on what could be changed in a business model.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Understanding of the business model

I can…

10. **…discuss components of business models.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

11. **…explain relevance of components of business models.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

12. **…provide solid interpretation of what business model components are.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

13. **…describe the components of a business model in my own words.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Idea-generation and business models

I can generate…

14. **…a sufficient number of ideas on how to change an existing business model.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

15. **…creative ideas on changing an existing business model.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

16. …high-quality ideas on how existing business models can be changed. *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

17. …different ideas on how existing business models can be changed. *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

Decision making and business models

I can...

18. …make recommendations regarding business model changes. *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

19. …estimate the consequences from a change in a business model. *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

20. … make trade-offs on what should be changed in a business model. *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

21. ... identify the most effective business model changes. within a set of alternatives.
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

Post-questionnaire

We would like to know how you experienced the tool, and what we could improve. Therefore, we have again a short questionnaire, taking you no more than 4 minutes, but helping our business model research tremendously!
Your input will only be used for academic research purposes, and will not be shared. All data is anonymized and analyzed on an aggregated level.

*Required

1. **Please add your Prolific ID.** *

To which extent do you agree with the following statements?

2. **Overall, I am satisfied with the ease of completing the tasks.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

3. **Interacting with this tool requires a lot of mental effort.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

4. **The objectives were clear to me.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

5. **The activities stimulated my personal learning.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Understanding of the business model components

After the use of ΩmeGA business model tool I can…

6. **…discuss the components of business models.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

7. **…explain the relevance of components of business models.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

8. **…provide solid interpretation of what business model components are.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

9. **…describe the components of a business model in my own words.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

Idea-generation and business models

After the use of ΩmeGA business model tool I am able to generate…

10. **…a sufficient number of ideas on how to change an existing business model.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

11. **…creative ideas regarding what I can change on an existing business model.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	⬭	⬭	Strongly agree

12. **…high-quality ideas on how existing business models can be changed.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

13. **…different ideas on how existing business models can be changed.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Decision making and business models

After the use of ΩmeGA business model tool I am able to…

14. **…make recommendations regarding business model changes.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

15. **… make trade-offs on what should be changed in a business model** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

16. **... identify the most effective business model changes. within a set of alternatives.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

17. **What is your level in English?** *
Mark only one oval.

◯ A0-A1 (Basic communication)
◯ B1-B2 (Advanced communication)
◯ C1-C2 (Excellent communication)

ΩmeGA
Understand, Generate, Assess

Participate in our research!

We're very interested to learn how our own-developed ΩmeGA business model tool helps you to learn about business model innovation. Therefore, we'd like you to fill out a short questionnaire before and after you use the tool. It will take no more than 4 minutes to answer the questionnaire. Your input will only be used for academic research purposes and will not be shared. All data is anonymized and analyzed on an aggregated level.

Before you continue, can you make sure you have a working version of Microsoft Excel or Libra Office? If not, you can download Libra Ofice for free from here. Now you can continue.

Please click here to answer the pre-questionnaire. It's important that you answer the questionnaire *before* you go to the next task.

Case description: `Rentals anytime'

You're the innovation manager at `Rentals anytime', a typical car rental company. It's a medium-sized company that has been in business since 2001. The company mainly makes money by renting out cars. The cars that are being rent out are bought new and resold after some time. Furthermore, the company rents out additional related products (e.g. navigation system and child car seats), while also offering additional services (e.g. car insurance, fuel packages, and electronic toll collection systems).

The owner of the company calls the managerial team of *Rentals anytime* and you, the innovation manager, for a meeting. The purpose of the meeting becomes clear quite quickly: The owner wants you to come up with advice on how the company **can add value from digital technologies**.

In this scenario, you'll come up with that advice through three tasks. To execute the tasks, you need to **download** the ΩmeGA business model tool from here **Please, download the excel sheet so you can get the full functions.** (Microsoft Excel) **or** here (LibraOffice).

Task 1: Describe the current business model

You go back to your office and you realize something. How can you come up with an advice if you don't have a clear overview of how the business model looks now? Your first task is therefore to describe the current business model of the company.

Go to the second tab of the spreadsheet named **TASK 1**. Fill out the boxes in the tab to describe the current business model of the company. Maybe you need to make a few assumptions on top of what we explained about the company: that's fine! The purpose of this task is to lay the basis for making a new business model for the company. The TASK is not about the correct answer but for you to get familiar with the concept of business models! **(When you complete task 1 please return to this document).**

Task 2: Design a new business model

Now, that you have an overview of the existing business model. it is time to take a look at the owner's request: How can we take advantage of digital technologies?

As you think about the case, you identify two major trends. One is *shared mobility*. People no longer want to own a car – they just want to use one whenever they need it. Another is the *Internet of Things*. With the Internet of Things, soon all the things around us will become internet-connected – including cars! Would these two trends open up new business opportunities to the company?

You might come with different ideas! We will help you by giving you a small hint on how the business model could be changed. Your idea is to change the business model into a car2go business model. The new offering will be that customers can access and use one of the available cars parked somewhere at the city for just a short period of time, up to two hours within the premises of Amsterdam city. Of course, that requires new technical requirements and alteration of the business model.

In this task, you'll come up with a new business model for the car sharing idea. What needs to be changed or added to the current business model from the first task? Please go back to the ΩmeGA business model tool and continue with the next tab **with the name TASK 2**. Select the business model option that you think fits best. There's no right or wrong answer – the point is to think and come up with a solution your boss would find interesting! If you think that nothing needs to be changed, the 'old' business model might work as fine!

(When you complete task 2 please return to this document).

Task 3: Evaluate your new business model

So now you have a new business model to design for the company. But how do you get there from the current business model? The final step is to evaluate the new business model and the necessary changes. Is it possible to implement it? Answering this question will help you make a clear pitch to your boss.

In this task, you'll evaluate each change that you proposed. The tool will tell you what to consider. Maybe you'll find that your changes are evaluated favorably – or maybe not at all? Don't worry: the goal of the task is to understand which ideas can be implemented and which cannot.

Please go back to the ΩmeGA business model tool and continue with **the fourth tab with the name TASK 3. (When you complete task 3 please return to this document).**

Congratulations on completing the assignment!

No matter what the outcome is now, you probably have some suggestions to present in the next meeting with the owner of the company.

Post-questionnaire

We would like to know how you experienced the tool, and what we could improve. Therefore, we have again a short questionnaire, taking you no more than 4 minutes, but helping our business model research tremendously!

Your input will only be used for academic research purposes and will not be shared. All data is anonymized and analyzed on an aggregated level.

Please click here to answer the post-questionnaire.

Thank you again for your participation and contribution to our research!!
For any comments, feedback, discussions please conduct us at A.Athanasopoulou@tudelft.nl

Summary

Opportunities such as digital technologies are fundamentally reshaping businesses. Enterprises are moving from selling physical products and services, to providing digitally enabled services. Enterprises need to rethink their business models and how to adapt them to take advantage of these opportunities.

How to adapt the existing business model is not always obvious or clear how to do it and business model exploration is needed. However, there is a lack of research on business model exploration. With business model exploration, enterprises can discover new business model opportunities, get new business model ideas, and create competitive advantage. Scholars argue that a way to support the transformation of business models is to develop business model tools. However, there is no clear indication of whether business model tooling contributes to the exploration and the process from an existing business model to a new one. Additionally, existing business model tools are mainly focused on formalizing one specific business model design, rather than facilitating the systematic exploration of alternative business models. ***(Chapter 1)***

We present the research approach we followed for this study. We discuss the main research approach we adopted, namely the design science research (DSR) approach, which gave the study a structure, that is, awareness of the problem, design, development, evaluation, and communication (i.e., conclusion). Using a DSR approach enabled us to have a structured approach to how to turn theory into an artifact following the "build–evaluate–iterate" approach. ***(Chapter 2)***

We reviewed the business model related literature. While many studies focus on these topics, unique definitions of what a business model is are not available. For that reason, we present a review of the existing definitions from the literature and argue why we adopted specific ones. Recently, studies have focused on how a business model is a set

of "building blocks." Hence, business models consist of components. We argue that thinking of a business model as a unit and not as a set of components is one of the main problems with the use of business models, because users do not think of their business model as a set of components and may have trouble filling them out. We then focus on the business model innovation process. We present a review of the definition and identify the phases of the process. We state that the business model design phase is the main focus of the existing literature, but lately, interest has switched to business model exploration, experimentation, and implementation. We say that generating ideas on how to change different business model components is an important first step in business model innovation. Furthermore, we say that making decisions about whether to adapt the components in the business model is a prerequisite to business model implementation. Next, we focus on the business model tooling literature, as the aim of this study was to create a tool for the previously identified problem. We first present the existing tools developed by academics and practitioners and identify what is available and what is missing. We state that the majority of the existing tools are focused on the business model design without taking into account that there might be more than one answer to how a business model can be. We also state that while most studies on business models describe the business model concept as a set of specific components when we reviewed the available business model tools we found that they do not take that into consideration and they require users to start creating or revising their business models without being aware of this. One more point we identified from reviewing the existing business model tools is that many of them are more focused on designing the business model and far less on implementing it. Currently, there are not many tools that have evaluation metrics to help assess the feasibility of the generated ideas regarding the business model. However, understanding the feasibility is a prerequisite for deciding whether to implement a business model change. ***(Chapter 3)***

Next, we focus on how disruptive technologies are affecting the business models of mobility-related enterprises. We used the Q-methodology as the research approach, and focus on how disruptive technologies are affecting the business models of the mobility-related enterprises. We find out that the need for completely new business models but for revising some of the existing business model components. We focused on the Internet of Things (IoT) as a relatively new technology with potentials to affect major parts of the society and, hence, the industries. ***(Chapter 4)***

We followed action research methodology, aiming to arrive at a set of testable design principles for the design of a business model exploration tooling. ***(Chapter 5)***

We developed a working prototype following the identified design principles. The main decision regarding this tooling is that this prototype will allow the evaluation of the design principles. ***(Chapter 6)***

We used an experimental design approach to evaluate the developed business model tooling. The design principles served as the hypotheses to be tested and be confirmed or get rejected. In total, 192 participants took part in the experiment. From our results, we can infer that the pre-filled template, was significantly useful for the users to understand the business model components. While explaining the relevance of the business model components, after the use of the tooling was not significant, overall the results indicated that the tooling supported the users' understanding. The results indicate that the use of solution-based patterns had a positive influence on the idea generation process regarding what can be changed in the business model exploration process. The 'solution based patterns' were not previously used and from our findings, we can indicate that tooling with this functionality could be used for idea generation processes, brainstorming, and business model exploration. Our results did not indicate significant positive improvement. Therefore, we cannot argue that the assessment features as a business model functionality to support the decision-making activity of the business model exploration. ***(Chapter 7)***

This study is one of the first on designing and evaluating a tool specifically for business model exploration, as we had found that business model exploration requires different tools because, as revealed by our action research, it is not known exactly what should be done, when, and by whom. In addition, we tested existing business model tooling in practice, and while the tools were useful they insufficiently address business model exploration. This study is the first to develop a specific tool for business model exploration and to show its impact through an experiment. Furthermore, our study contributes to the business model tooling literature in the form of our evaluation approach, which could be used as a guideline to test various business model tooling functionalities. Finally, related to the elements, our study is the first to review the business model IoT literature and, based on this review, identify the elements related to IoT. Studies could use these elements to revise business model ontologies taking into consideration the IoT technology.

Out study serves as a basis for future research interesting for academics doing research in the field of business models, ICT's and industrial engineering. we suggest that future research could combine business model innovation, collaborative design, and consumer behavior in the context of an increasingly complex entrepreneur ecosystem. Such research could focus on the business models from the applied context of service (or product) development perspective (e.g., organization, consumer research, marketing research) and technology influence. In addition, agility could be the main focus, taking into account the design teams, the product developers, and how the products or services to be developed fit the organization's business identity, and what the digital tools are that could support this agile approach, and at the same time how the business identity affects the design of products. ***(Chapter 8)***

Samenvatting

Verkenning van bedrijfsverandering: het ontwerp van een digitale tooling voor bedrijfsmodelverkenning (business model exploration) voor het automotive ecosysteem.

Digitale technologieën, zoals the Internet of Things (*IoT*), vragen om fundamentele hervormingen van bedrijven. Ondernemingen stappen over van de verkoop van fysieke producten en diensten naar digitale diensten. In deze veranderende context moeten bedrijven hun bestaande bedrijfsmodellen heroverwegen en opnieuw uitvinden om te kunnen blijven concurreren. Organisaties moeten hun bedrijfsmodellen heroverwegen en aanpassen aan een gedigitaliseerde wereld. Hoe het bestaande bedrijfsmodel moet worden aangepast is echter niet altijd duidelijk, daarom is verkenning van bedrijfsmodellen (*business model*) nodig. Er is echter een gebrek aan onderzoek naar de verkenning van bedrijfsmodellen, vooral voor specifieke domeinen zoals de auto-industrie. Bedrijven kunnen bij radicale veranderingen ondersteund worden door middel van verkenning van bedrijfsmodellen. Met deze verkenning kunnen ondernemingen nieuwe mogelijkheden voor bedrijfsmodellen ontdekken, ideeën voor nieuwe bedrijfsmodellen op doen en een concurrentievoordeel creëren. Een manier om de verkenning van bedrijfsmodellen te ondersteunen is de ontwikkeling van bedrijfsmodelhulpmiddelen. (*business model tooling*) Het doel van deze studie is om hulpmiddelen te ontwerpen om businessmodelverkenning te ondersteunen. ***(Hoofdstuk 1)***

Om onze onderzoeksdoelstelling te bereiken, volgen we een Design Science Research-aanpak (*DSR*). Met behulp van DSR konden we de theorie op gestructureerde wijze omzetten in een artefact volgens de 'bouw-evalueer-itereer'-benadering. We hebben onze studie gestructureerd op basis van de DSR-activiteiten: (a) bewustwording van het probleem, (b) ontwerp, (c) ontwikkeling, (d) evaluatie en (e) communicatie. ***(Hoofdstuk 2)***

We hebben de bedrijfssmodelliteratuur bestudeerd. De meeste bestaande tooling blijkt gericht op het ontwerp van het bedrijfsmodel zonder rekening te houden met het feit dat er meer dan één antwoord kan zijn op hoe een bedrijfsmodel er uit kan zien. Uit de beoordeling van de huidige beschikbare bedrijfsmodeltooling volgt dat het meeste onderzoek over bedrijfsmodellen het bedrijfsmodelconcept beschrijft als een reeks specifieke patronen. Echter, de bestaande modellen nemen deze herhalende patronen niet in acht, waardoor gebruikers in veel gevallen gebruik maken van tooling zonder zich bewust te zijn van mogelijke herhalende patronen. Bovendien is veel van de tooling vooral gericht op het ontwerpen van het bedrijfsmodel en veel minder op de implementatie ervan. Tenslotte is er niet veel tooling met statistieken ter evaluatie die helpen bij de beoordeling van de haalbaarheid van de gegenereerde ideeën voor het bedrijfsmodel. Begrip over de haalbaarheid is echter een vereiste om een beslissing te kunnen nemen over de implementatie van een verandering in een bedrijfsmodel. ***(Hoofdstuk 3)***

Vervolgens concentreren we ons op de manier waarop disruptieve technologieën de bedrijfsmodellen van mobiliteitsgerelateerde ondernemingen beïnvloeden. We gebruiken hiervoor de Q-methodologie (*Q-methodology*). We ontdekken dat volledig nieuwe bedrijfsmodellen niet nodig zijn, het gaat veeleer om het herzien van enkele van de bestaande componenten van het bedrijfsmodel. We hebben ons gericht op IoT als een relatief nieuwe technologie met het potentieel om grote delen van de samenleving, en daarmee de industrieën, te beïnvloeden. ***(Hoofdstuk 4)***

Na een actieonderzoeksmethodiek (*Action Research*) identificeerden we drie ontwerpprincipes voor het ontwerpen van een business model exploratie tooling. ***(Hoofdstuk 5)***

We gaan verder met de beschrijving van de ontwikkeling van de tool. We hebben een werkend prototype ontwikkeld volgens de eerder vastgestelde ontwerpprincipes. De belangrijkste beslissing met betrekking tot deze tooling is dat dit prototype de evaluatie van de ontwerpprincipes mogelijk zal maken. ***(Hoofdstuk 6)***

Vervolgens gebruiken we een experimentele ontwerpaanpak (*experimental design approach*) om de ontwikkelde tooling voor bedrijfsmodellen te evalueren. De ontwerpprincipes dienen als de hypothesen, welke worden bevestigd of afgewezen. In totaal namen 192 deelnemers deel aan het experiment. De resultaten laten zien dat het vooraf ingevulde sjabloon significant nuttig was voor de gebruikers om de bedrijfsmodelcomponenten te begrijpen. Daarnaast geven de resultaten weer dat het gebruik van oplossingsgerichte patronen een positieve invloed had op het genereren van ideeën over dat wat veranderd kan worden in een bedrijfsmodelverkenningsproces. De oplossingsgerichte patronen waren niet eerder gebruikt en de resultaten laten zien dat tooling met deze functionaliteit gebruikt kan worden voor het genereren van ideeën, brainstorms en bedrijfsmodelverkenning. De resultaten lieten geen significant positieve verbetering zien. Daarom kunnen we niet stellen dat de evaluatie dient als functionaliteit van het bedrijfsmodel ter ondersteuning van besluitvormingsactiviteiten bij bedrijfsmodelverkenningen. ***(Hoofdstuk 7)***

Dit is een van de eerste studies die zich specifiek richt op de verkenning van het bedrijfsmodel en de academische discussie over tooling voor bedrijfsmodellen. De studie biedt inzicht in functionaliteiten die de verkenning van het bedrijfsmodel kunnen ondersteunen. Het gebruik van de tooling in een praktische leeromgeving heeft de potentie om bedrijfsmodelinnovatie-activiteiten (BMI) te verrijken waaronder verkenning, ontwerp en implementatie in brainstormsituaties. Daarnaast heeft het de potentie om pedagogische hulpmiddelen voor educatie op het gebied van bedrijfsmodellen te verbeteren. Toekomstig onderzoek zou een holistische benadering kunnen gebruiken voor onderzoek naar BMI, collaboratief ontwerp en consumentengedrag in de context van een steeds complexer wordend ecosysteem van ondernemers. Dit onderzoek zou zich kunnen richten op bedrijfsmodellen vanuit het perspectief van dienst- of productontwikkeling (bijvoorbeeld organisatie, consumentenonderzoek, marktonderzoek) waarbij de invloed van nieuwe technologieën in acht moet worden genomen. Dit onderzoek kan interessant zijn voor academici die onderzoek doen op het gebied van bedrijfsmodellen, ICT en industriëel ontwerp. ***(Hoofdstuk 8)***

Συνοπτικη Περιληψη

Εξερευνώντας τις αλλαγές στις επιχειρησεις: Ο σχεδιασμός ψηφιακού εργαλείου για εξερεύνηση επιχειρηματικών μοντέλων στην αυτοβιομηχανία.

Οι ψηφιακές τεχνολογίες, όπως το IoT, αναδιαμορφώνουν πλήρως τις επιχειρήσεις. Οι επιχειρήσεις αλλάζουν από την πώληση φυσικών προϊόντων και υπηρεσιών στην παροχή ψηφιακών υπηρεσιών. Δεδομένου ότι το επιχειρησιακό περιβάλλον αλλάζει, οι επιχειρήσεις πρέπει να επανεξετάσουν και να εξερευνήσουν πάλι τα υπάρχοντα επιχειρησιακά μοντέλα τους για να μείνουν ανταγωνιστικές. Οι επιχειρήσεις θα πρέπει να ξανασκεφτούν τα επιχειρησιακά μοντέλα τους και πώς να τα προσαρμόσουν προκειμένου να συμμετέχουν στο ψηφιακό κόσμο. Ωστόσο ο τρόπος πώς να προσαρμοστούν υπάρχοντα επιχειρησιακά μοντέλα δεν είναι πάντα προφανής. Προτείνουμε ότι είναι απαραίτητη η εξερεύνηση επιχειρησιακών μοντέλων. Εντούτοις, δεν υπάρχει επαρκής ακαδημαική βιβλιογραφία για την εξερεύνηση επιχειρησιακών μοντελων ειδικά για συγκεκρημένου ίδους βιομηχανίες όπως είναι η αυτοκινητοβιομηχανία. Με την εξερεύνηση επιχειρησιακών μοντέλων, οι επιχειρήσεις μπορούν να ανακαλύψουν νέες ευκαιρίες για τα επιχειρησιακά μοντέλα, και να δημιουργήσουν ένα ανταγωνιστικό πλεονέκτημα. Ένας τρόπος να υποστηριχθεί η εξερεύνηση επιχειρησιακών μοντέλων είναι με την κατασκευή πρακτικών εργαλείων. Ο ερευνητικός στόχος αυτής της μελέτης είναι ο σχεδιασμός και η κατασκευή ενός πρακτικού εργαλείου (BMT) το οποίο να υποστηρίζει τη διαδικασία της εξερεύνησης επιχειρησιακών μοντέλων.

Η αναλυση των αποτελεσματων έδειξε ότι το πρακτικό εργαλείο (BMT) βοηθάει στην κατανόηση των συνιστωσών των επιχειρηματικών μοντέλων, και σε μεγαλύτερη έκταση βοηθάει στην ΄γέννηση΄ ιδεών σχετικά με την αναθεώρηση των επιχειρηματικών μοντέλων, ενώ η χρήση του εργαλείου έδειξε ότι δεν βοήθησε τους συμμετέχοντες να πάρουν αποφάσεις σχετικά με αλλαγές στο επιχειρησιακό μοντέλο.Η διδακτορική μας μελέτη ολοκληρώνεται με τη παρουσίαση της συνεισφορά μας στη επιστήμη των επιχειρηματικών μοντέλων, με τη δημιουργία ενος νέου BMT που υποστηρίζει τη εξερεύνηση των επιχειρησιακών μοντέλων.

Publications and Presentations by the Author

1. Athanasopoulou, A., De Reuver, M. and Janssen, M. *Evaluating tooling functionalities for business model exploration:An experimental design approach.*
   Under preparation

2. Athanasopoulou, A., De Reuver, M. *The role of tooling and agility in business model exploration: Evidence from action research.* Special issue on Business models and tooling, Electronic Markets.
   Under review

3. Athanasopoulou, A., De Reuver, M., Nikou, S., Bouwman., H. (2019). What technology enabled services impact business models in the automotive industry? An exploratory study. *Futures*, Volume 109, May 2019, Pages 73-83. 10.1016/j.futures.2019.04.001.

4. Athanasopoulou, A (2018). *Exploring the business model potentials: The design of digital tooling for business model exploration.* In BOSCH BMI Summit 2018, Stuttgart, Germany.
   Poster presentation

5. Athanasopoulou, A., De Reuver, M., (2018). *Designing business model tooling for business model exploration: An experimental design for evaluation.* Proceedings of the 29th Bled eConference, Bled, Slovenia.

6. Athanasopoulou, A., De Reuver, M., Haaker, T, (2018) *Tool for Internet-of-Things business model exploration: A Design Science Research Approach.* In ECIS 2018, Portsmouth, UK.
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8. Athanasopoulou, A., De Reuver, M. Roelfsema, M., Kosman, R. (2018) *Understanding business model innovation in practice: Recommendations for future business model tooling by an action research.* In Proceedings of R&D conference, Milan, Italy.

9. Athanasopoulou, A. (2018) *Business Model Innovation in the IoT era: The design of a software-based tooling for Business Model exploration.* In Proceedings DESRIST 2018 Doctoral Consortium, In Desrist 2018, Chanai, India

10. Athanasopoulou, A., de Reuver, M. Roelfsema, M., Kosman, R., Celino, I., Agrawal, N., Re Calegari, G., Villedieu, F., Seizou, M., Tirane, S., Verioli, A., Pollini, A. (2017) *D1704. Ninja Riders Business Report.* EIT Digital.
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11. Athanasopoulou, A (2017) *Towards an IoT Business Model Innovation tooling for Small and Medium Enterprises.* IN ECIS 2017 Doctoral Consortium, 25th European Conference on Information Systems Guimaraes, Portugal.

12. Bouwman, H., Athanasopoulou, A., and De Reuver, M. (2016). *The disruptive impact of digitalization on the automotive ecosystem: a research agenda on business models, platforms and consumer issues.* Proceedings of the 29th Bled eConference, Bled, Slovenia.

13. De Reuver, M.; Athanasopoulou, A.; Haaker, T.; Roelfsema, M.; Riedl, A.; and Breitfuss, G., (2016). *Designing an ICT tooling platform to support SME business model innovation: Results of a first design cycle.* BLED 2016 Proceedings. 7.

Curriculum vitae

'She came from Greece she had a thirst for knowledge. . . ' [1]

Alexia Athanasopoulou (*Αλεξία Αθανασοπούλου*) was born in Patras, Greece (*Πάτρα, Ελλάδα*) on March 13, 1989. Upon finishing high school education with honors, she received both BSc and MEng from the department of Computer Engineering and Informatics from the University of Patras, Greece (5 years mandatory program). She continued her studies at University of Strathclyde, (*Glasgow, Scotland*) where she was awarded an MSc in Information Management *with Distinction*.
Directly after, she was accepted as an intern at the European Commission supporting activities in Joint Research Centre, *JRC* (the scientific Centre of European Commission) in Ispra, Italy (*Ispra, Italia*).
As soon as she completed her internship, she was admitted as a fully-funded Ph.D. researcher in the ICT section of the Faculty of Technology Policy & Management of the Delft University of Technology in Delft, The Netherlands (*Delft, Nederland*). Her Ph.D. study was part of the ENviSION Horizon 2020 project. During her PhD, she participated at Ninja Riders project (EIT Digital-Digital Cities Action Line, activity 17091).
During her Ph.D. she coauthored papers, took different teaching responsibilities such as teaching assistant, supervisor and guest lecturer. To carry on her research interests she participated and she gave presentations in conferences (*ECIS, DESRIST, eBled, R&D*), meetings summer schools, doctoral consortia (*ECIS 2017, Desrist 2018*), peer groups, and various workshops. For 2017-2018 she was the colloquium coordinator of the ICT section of the Department of Engineering Systems and Services.

[1] Pulp, Common People, `https://www.youtube.com/watch?v=yuTMWgOduFM`