Valuing Investments in Digital Business Transformation: A Real Options Approach

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ABSTRACT

Emerging digital technologies represent major challenges for established corporations around the world. To succeed in this rapidly changing environment, it is no longer sufficient to compete by incremental product innovations. Achieving sustainable competitive advantage requires managers to exploit the disruptive potential of technology by transforming business models, value chains or entire markets. Digital Business Transformation (DBT) is defined as a significant change in an established company's business model driven by digital technology. It is a necessary tool to adapt business models in the rapidly changing business environment. In this context, managers are facing the challenging task of finding the right investment decisions. Standard project valuation models such as the Net Present Value (NPV) method do not capture managerial flexibility, which is particularly valuable in risky Digital Business Transformation projects. In this context, Real Option Analysis can be applied as a sophisticated alternative for investment decision making. So far, no research has been conducted on the interface between DBT and Real Options Theory. In this paper, we present our approach to valuing the option to expand from a trial project into a large-scaled transformation project by including the business-related uncertainty surrounding DBT and show that this option has the potential to shift traditional investment decisions. This paper is aiming to highlight the importance of this area, develop simple methods to cope with it and lay the foundations for future research.

Keywords: Real Options, Digital Transformation, Business Model Innovation, Option to Expand

1. Introduction

Disruptive technologies and exponential technological progress are framing today's business environment across all major industries. For many businesses, expressions such as Big Data, the Internet of Things (IoT), 3D printing, Artificial Intelligence etc., are still only buzzwords that are yet to be implemented into business strategies. On one hand, this global development opens many opportunity windows for existing businesses, as well as new ventures around the world, to achieve strategic competitive advantage, expand business models or enter into entirely new markets. On the other hand, however, these trends are a major threat for established companies, as many of them struggle to keep up with the pace of the developments, lacking the skills to compete with mushrooming tech-newcomers that are unsettling traditional value chains. In today's digital economy, established corporations have to exploit digital technologies to innovate their business models. In other words, they have to proactively invest in Digital Business Transformation initiatives.

Standard investment decision models in Corporate Finance Theory include the Discounted Cash Flow (DCF) analysis, or Net Present Value (NPV) techniques. Practitioners frequently apply these methods for Information Systems (IS)/ Information Technology (IT) investments. However, these methods do not suffice in coping with high levels of uncertainty, as they do not capture managerial flexibility, neither before nor after an investment is taken. Hence, these methods systematically undervalue projects in high uncertainty situations such as the Digital Transformation setting. Real Options Theory is concerned with valuing this managerial flexibility and finding the right timing of such investment decisions. A broad variety of literature has suggested applying Real Option Valuation for investment decision making. However, so far, literature has focused on applying Real Option Theory to different kinds of projects with crucially different characteristics such as pure IT investments, energy, mining, oil or Research and Development (R&D) projects. In practice, trial projects are a useful tool for uncertainty resolution. These projects include the option to expand into larger digital transformation initiatives if new information is in favor of the project's success. In this paper we present our first approach to extending traditional capital budgeting techniques by including the option to expand from a trial project into a large-scaled transformation project.

This study is aiming to increase the understanding of Digital Business Transformation and highlight the need for special treatment of related investments. It advocates Real Options Analysis (ROA) as a sophisticated tool for strategic decision-making and lays the foundations for future research. This paper provides an answer to the following research questions:

1. What is Digital Business Transformation?
2. Why is it essential to improve existing capital budgeting techniques in this context?
3. How can investments in DBT be valued to cope with business-related uncertainties and include the inherent value of managerial flexibility?

The structure of this paper is based on four sections. First, we present the motivation of this study based on the increasing need for DBT resulting from current trends and technological shifts in the digital economy and derive a generic definition of the term Digital Business Transformation. Second, we describe the specialties of investments in DBT and explain importance of managerial flexibility related to these projects. Third, we present a simple approach to how we can apply ROA in the context of valuing DBT and test the model against the real-world business case of Amazon Go. The final section summarizes and concludes the study results.

2. Understanding Digital Business Transformation

2.1. Doing Business in the Digital Economy

Humanity is currently facing times of severe changes triggered by emerging digital technologies. Technological developments are not gradually increasing but skyrocketing exponentially. Living in a world determined by exponential change entails extensive implications for society, politics and the economy. In today's digital age, it would be detrimental for businesses to continue with linear thinking. When it comes to aligning businesses, facing these developments is no longer about simply digitizing business processes; it is about transforming business models to convert into entirely different organizations. In short, it is about creating something new, rather than just soliciting a process of adaption. In the near future, industry leaders, even in traditional industries such as automotive or financial services, will be tech companies. Successful innovators such as Amazon, Google, Microsoft, Apple and Salesforce that have only existed a few decades are now among the largest companies in the world (Fortune, 2017). Additionally, traditional corporations are increasingly converting into tech companies, as the economy and the business environment further digitalizes.

A well-observable example for this development is the automotive industry. Car manufacturers' traditional asset-based business models are about producing and selling vehicles. Yet, due to technological developments, they are facing the challenge to transform into organizations that sell mobility services based on digital platforms and self-driving electric vehicles. An existing example is the car-sharing platform DriveNow, a collaborative project by BMW and Sixt, that already has close to one million customers in 16 cities across 10 countries. According to a recent study, 75% of the fortune 500 CEOs said that *"[…] a trio of technologies – cloud computing, mobile computing and the Internet of Things – will be either 'very important' or 'extremely important' to their businesses in the future"* and more than 50% added Artificial Intelligence and Machine Learning to the list (Murray, 2016). This phenomenon is already observable today. So-called nightmare competitors such as Uber or Google introduce their innovative technology-enabled concepts unsettling traditional value chains and replacing established market leaders. We are facing an era in which the standards of business practice are increasingly set by innovative startups rather than by existing market leaders. Executives of established enterprises have started to realize this phenomenon investing $1.2 trillion in worldwide spending on Digital Transformation technologies in 2017 (IDC, 2017).

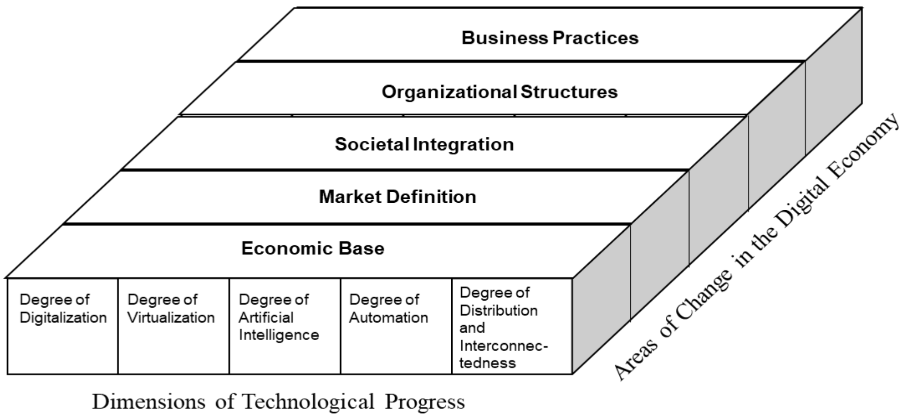

Figure 1: Determinants of change in the digital economy
(Source: own illustration based on (Leonhard, 2016) and (Parker, 1995))

Figure 1 summarizes the determinants of paradigmatic change in the digital economy. It illustrates the different dimensions of technological progress and their impact areas flowing together to create a

VUCA world.[1] Technological progress can be clustered in five dimensions that are expected to have a severe impact on the determinants of the digital economy. These dimensions are highly interdependent unfolding enormous disruptive potential. These developments indicate the need of smart adaption of established enterprises to avoid Digital Darwinism.[2]

Degree of Digitalization: analogue source material is increasingly transformed into numerical systems (data) enabling content management by digital information systems. Traditional products and services are digitized and new digital products and services are created. What used to be unobservable behavior or thoughts in the past is being transitioned into tangible data. Data analytics methods are becoming increasingly sophisticated and practicable, based on the availability of learning algorithms and exponentially increasing computational power. Data analytics algorithms increase predictability of individual behavior. Human thoughts and behaviors are becoming increasingly transparent while data is transforming into the core resource for value creation. Digital technology is increasingly facilitating individual solutions and multifaceted adaptions of products and services to individual preferences.

Degree of Virtualization: What used to be real is increasingly transferred into the cloud. Tangible market places and asset-based business models are transforming into virtual meeting points and digital platforms. Assets are no longer at the core of doing business and the concept of ownership is converting into use as a service concepts distributed via online sharing platforms. Technologies are increasingly applied to extend the reality virtually. The line between the physical and the virtual world is dwindling. Virtual and augmented reality technologies are not only applied to create a new experience in the gaming industry. They are increasingly applied to eliminate the need of production of physical prototypes and to simplify planning and predictability of complex construction, engineering and manufacturing projects.

Degree of Artificial Intelligence: simple machines are transforming into cognitive systems with increasingly sophisticated artificial intelligence. An increasing number of tasks can be taken care of by robots. Proceedings in disciplines such as Machine Learning, Cognitive Robotics and Human-Robot Interaction have reached an unprecedented pace. Robots are no longer used only in industrial manufacturing. They are preparing to transform into intelligent companions in our every-day public, professional as well as private lives.

Degree of Automation: processes are increasingly being automated and optimized by an increased degree of digitalization. Friction points and transaction costs are eliminated. Smart factories have reached manufacturing industries using flexible, modularized and highly automated production lines while big data and the IoT boosts productivity applying emerging concepts such as predictive maintenance and additive manufacturing. The role of intermediaries is becoming increasingly obsolete, due to all-time transparency of supply and reactivity of end users enabled by digital technology.

Degree of Distribution and Interconnectedness: data and services are becoming available anytime and anywhere via mobile devices, irrespective of access time and/or client location. Technologies such as Blockchain, Bitcoin, IoT, Big Data, Networks, Platforms enable distributed systems and operations on a global scale.

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[1] VUCA, which is an acronym for the words Volatility, Uncertainty, Complexity and Ambiguity, has recently found its way into the business lexicon. It is a concept that describes the unpredictable nature of the times currently confronted by managers (Bennett & Lemoine, 2014). Especially in the digital economy, it can provide a framework that helps managers to understand how much they know about their situation and how well they can predict the result of their actions by capturing the characteristics along these four dimensions.

[2] In the rapidly changing digital economy, businesses will digitalize or die – a phenomenon that can already be observed in practice and is recently being referred to as Digital Darwinism (see for example Kreutzer, 2014).

Economic base: The digital economy has become a frequent keyword in recent publications on management and business informatics. The term basically describes an economy that is based on the digitization of information and the respective information and communication infrastructure. It refers to the phenomenon that the way, in which economic values are created, produced, distributed and exchanged, changes fundamentally in the digital economy (Zimmermann, 2000). While the transformation from physical goods into digital goods and the development of new purely digital goods is at the core, a fundamentally different economic base is created, reforming traditional business models and partnerships (Rayna, 2008).

Market Definition: digital technology has made globalization of business possible. Due to technologies such as the World Wide Web and the emergence of digitalized products and services, companies are no longer competing on local but global markets. In today's economy, companies from the US, China and Japan are competing for customers located in Europe using the internet and other digital platforms as their global distribution network. Even across various borders and time zones, transactions have been made more efficient, transparent, and quick and processes are increasingly automated. These developments are expected to continue in the future. Driven by the rapidly increasing coverage of broadband connections combined with continuously decreasing regulatory trade barriers and the rise of the cloud, Software as a Service (SaaS) solutions and virtualizing technologies, time to market has been significantly reduced and real-world proximity to customers eliminated.

Societal Integration: in today's digital society, technology is omnipresent. Digital technologies have spread from the workplace to homes and from schools to public places. Mobile technologies, such as smartphones and other mobile devices lead to permanent confrontation with digital components of existence in most individual's daily routines. With the increasing spectrum of functions of these devices, digital technologies will increasingly determine all aspects of information, communication and collaboration shifting customer needs to new levels. Additionally, the rising welfare in developing countries will further accelerate this trend as more and more of those countries seek entering the digital economy to join global competition in the scramble for market shares.

Organizational Structures: e-mail, remote workplaces, virtual meeting rooms, cloud platforms and the availability of operational information are all enablers of the more horizontally structured organization. Additionally, mobile technologies and digital platforms increasingly blur the boundaries of organizations enabling emergent concepts such as open innovation or collaboration networks with suppliers, customers and other business partners. In the digital economy, hierarchies are flattened and entrepreneurial spirit is gaining importance. Nowadays, successful organizations are risk-taking, dynamic and innovative rather than risk-averse, sluggish and conservative.

Business Practices: redefinition of the typical supplier-customer relationship, particularly at a global level, and conversion of the new ideas into action often depends on exploiting current digital capabilities. A more customer-centric approach to doing business could already be observed in the past and will play an even more important role in the future. Companies do not longer offer single products or services. Driven by digital technology, they will provide an end-to-end type of customer experience by selling highly personalized solutions.

The areas of change described above draw a picture about the severe uncertainties surrounding digital transformation investment decisions. They give an impression about the importance of Digital Transformation by established companies to avoid Digital Darwinism. The following section provides a definition of Digital Business Transformation, which shall determine the scope of investments that are under investigation by this paper.

2.2. *Definition of DBT*

Digital Business Transformation can be defined by regarding a firm's general Business Architecture. The Business Architecture encompasses the different layers and components that constitute a business. It can be defined as *"[...] a blueprint of the enterprise that provides a common understanding of the organization and is used to align strategic objectives and tactical demands"* (BIZBOK, 2017). Irrespective of size and industry, there are certain elements you will find in each company. While there are several versions of presenting the components of the Business Architecture, we present them based on the suggestions by Ferstl & Sinz, 2013 and Ullrich, 2013 illustrated in figure 2.

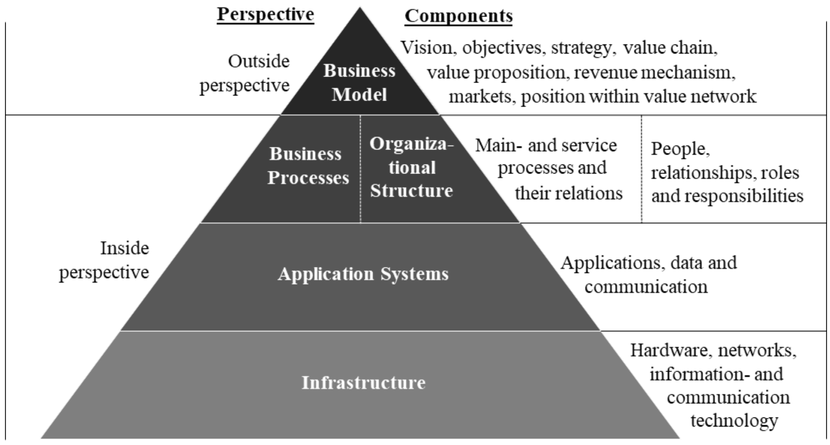

Fig. 2: The Layers of the Business Architecture
(Source: as presented by Ullrich, 2013 and Ferstl & Sinz, 2013)

The presented Business Architecture model consists of four layers: the business model, business processes and the organizational structure, application systems and the underlying infrastructure. The infrastructure layer describes the hardware and networks of a company and describes which information and communication technology is installed with the company (Krcmar, 1990). The application systems layer represents the company's applications, data and communication. It defines the elements and tools that are involved in the business processes used to create value. On the second layer, the business processes and the organizational structure are located. The organizational structure is responsible to implement the business strategy while the business processes give instructions about how this is achieved. The highest level in the Business Architecture is the business model. This layer represents the organization of the company from a strategic perspective. It "[...] *describes the rationale of how an organization creates, delivers, and captures value"* (Osterwalder & Pigneur, 2010). It represents the outside view on a business system (Ferstl & Sinz, 2013). It defines the functioning of the entire company and constitutes its identity. It formulates the vision, sets objectives and states the strategy to achieve them. Additionally, it defines the interfaces to the business environment and describes the connections and relationships with external parties. The business model is the determining factor of a company's core characteristics while lower layers in the business architecture are aligned to the business model ideally designed to enable the business model and implement its strategy in an economically viable matter.

All business components in the business architecture can be (and are frequently) subject to change as well as transformation. A transformation on the infrastructure layer is an infrastructure transformation, on the application systems layer an IT transformation, on the business process layer a process transformation and on the organizational layer an organizational transformation. As we move up the business architecture pyramid, uncertainty of related transformation initiatives increases, i.e. on the business model layer, uncertainty and the need of adjusting financial measures is most significant. This study is aiming to value investments in Digital Business Transformation. Hence, in the following, we focus on transformations on the business model layer.

The different components of a business model can be summarized by the four questions *“who?”, “what?”, “how?”* and *“why?”* (Gassmann et al., 2013). The answers to these questions concretize the business model’s customer segment, its value proposition, the value chain and the revenue model. Only a significant change in one or more of the answers to the four questions has the potential to shift a company’s core characteristics leading to a business transformation. A prominent and promising way to achieve a business transformation is Business Model Innovation (BMI). BMI creates new logic regarding how a company creates or captures value by making changes in the answers to the what, who, how and/or why questions. Business models subsume a vast scope, multiple interdependencies and side effects. In contrast to product or process innovation, BMI allows for additional innovation potential based on long-term strategic growth opportunities. It is able to shift existing industry boundaries and redefine markets or value chains. However, despite well-known examples such as Apple’s iTunes, BMW’s DriveNow or Amazon’s Kindle e-book reader, radical BMI remains to be elusive and highly risky. Therefore, transforming or innovating a business model remains a complex and challenging task. Digital Business Transformation is a BMI that is enabled or driven by emerging technologies. More precisely Digital Business Transformation (DBT) shall be defined as a significant change in an established company’s business model driven by digital technology. It is directed at the company’s vision, overall objectives or business strategy and affects a large number of stakeholders inside and outside the transforming organization as well as other entities in the business environment. Ultimately, DBT will lead to a shift in the firm’s core characteristics with the potential to disrupt traditional business practices.

2.3. Business Value of DBT

The corporate business strategy and its applied information systems are closely related. On one hand, information systems can support the corporate strategy and on the other hand, they can also provide the opportunity for new strategies. The relation between business strategy and information systems is illustrated in Figure 3. Information systems are aligned to support the corporate strategy. If they present an option to enter into a new strategy, we can speak of enablement. In the digital economy and based on the changing role of IT, the gap between the business domain and the IS/IT domain is becoming increasingly narrow. DBT is influenced by both the technology and the business domain. It is driven by new technologies for information systems, and directed to transform the business strategy. While Strategic Information System (SIS) investments increase competitive advantage through the new digital technology application, DBT is based on simultaneous change in both IS domain and the business model. Hence, digital business transformation investments can be seen as a hybrid form of IS/IT investment and business model transformation/innovation, which justifies for their strategic impact. As a consequence, the strategic importance of DBT typically exceeds the strategic importance of SIS investments. DBT is typically more long-term, more business-driven and more multifaceted than SIS investments. Ultimately, DBT means exploiting new digital technologies to create new SIS systems that engage transformational business model changes or innovations.

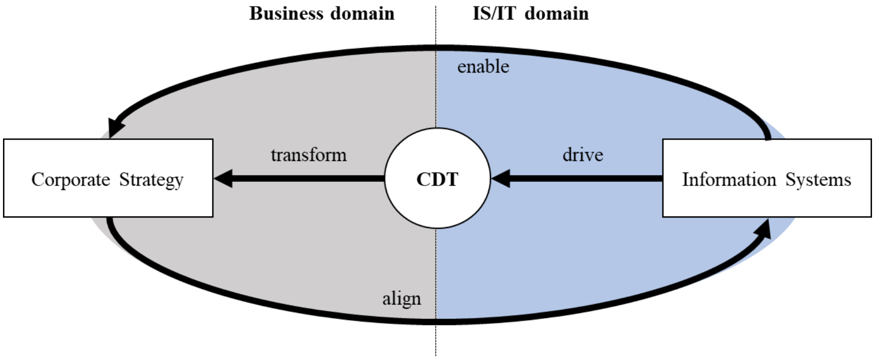

Fig. 3: DBT in the Strategic IS/IT Alignment Model
(Source: own illustration in extension of Krcmar (2015))

The hybrid nature of DBT projects indicates that, in addition to the competitive advantage generated by SIS, the business value of DBT encompasses an additional component: business model innovation. Business model innovation can aim at differentiation or cost advantage, often unguided by principles or theory (Zott & Amit, 2008). It is about achieving strategic competitive advantage by replacing the combined elements of "who", "what", "why", and "how" involved in providing customers and end users with products and services (Mitchell & Coles, 2003). While product innovations are aiming to rethink what is done, business model innovation rather focuses on changing how it is done. According to a study by the Economist Intelligence Unit, the majority of CEOs favored new business models over new products and services as a source of future competitive advantage (Borzo, 2005). Moreover, over the period of five years, business model innovators are on average six percent more profitable than pure product and process innovators (Gassmann et al., 2013). Business model innovation is often facilitated by technological innovations, which enable firms to organize and interact in new ways. However, business model innovators do not necessarily need to commit R&D investments to these technologies – it can also be achieved by deploying existing technologies in innovative ways (Amit & Zott, 2010). The combined benefits of a transformational business model innovation and the related SIS adoption constitutes the business value and strategic importance of DBT.

2.4. Risks in DBT investments

While the potential business value of DBT can be enormous, these projects are highly risky. According to IDC, 70% of Digital Transformation projects fail (IDC, 2015). DBT includes both creation of new SIS and business model innovation. Both approaches can be especially valuable in times of instability. However, business model innovation as well as SIS creation involve hefty investments, high levels of uncertainty, complexity and, inevitably, risk (Taran, et al., 2015). Risk relates to the uncertainty of outcome (Chapman & Ward, 2003). It can be seen as a threat to the success of a project leading to the stochastic nature of its financial results. We cluster the major risk factors of DBT in three groups: (a) business strategy-related risk, (b) technology-related risk, and (c) transformation-related risk, all playing a critical role in the success of DBT projects.

The business strategy-related risk inherent in DBT reflects the level of success of the business strategy itself, based on market dynamics, enterprise dynamics and timing. Business strategy risk focuses on the long-term risk surrounding competitive strategy and change in the market environment due to changing supplier-customer relationships, political realignments and demographic or regulatory trends (Parker, 1995). They include several different business aspects. Strategic investment decisions, such as business model innovations, affect the entire enterprise. They are long-term oriented and subject to the highly volatile business environment. Long-term investment decisions in a VUCA world are by nature highly risky. Projections of future customer needs and competitive actions have to be conducted in order to assess the potential of business model innovation in DBT. Estimating the costs and benefits of business model transformation is extremely difficult. Competitors might develop businesses or release solutions making the desired business model resulting from DBT obsolete. Moreover, customer needs may change or develop in different patterns than expected. Especially in case of entirely new markets, estimating profitability is extremely challenging, as no historic data exists. Business strategy risk in DBT is substantial and due to its exogenous nature, mitigation opportunities are limited. Business strategy risk can result in uncertainty over revenues as well as costs, which are the main determinants of a project's profitability. Sophisticated anticipation of future trends and developments and flexibility is essential.

Technology-related uncertainty in DBT refers to choosing and implementing the technologies that should drive the desired business model transformation. The choice of the right technologies is one of the key success factors in DBT. It comprises the typical dimensions of risk in strategic information system investment decisions. In this context, one of the core considerations will be the solutions and infrastructures that are used to implement a certain technology with the company. In the digital economy, it is hard to foresee the long-term persistence of certain technologies. Usually, there are several alternative IT-solutions with individual advantages and disadvantages. When investing into emerging technologies such as the Internet of Things or 3D-printing, it is not clear, which of the existing technologies will be the dominant solution in the future. Another technology-related risk is determined by the build-or-buy decision. There is the possibility to self-develop the required technologies with the in-house R&D department, which typically requires high up-front investments, comprehensive technological capabilities, and further (R&D-related) risks. On the other hand, buying the required technology from third parties might lead to a lock-in effect resulting in increased dependency and long-term inflexibility. Further IT-related risks in DBT relate to IT scalability, compatibility, security, integrity and availability. IT-based risks are partially exogenous (technological progress) and partially endogenous (technology deployment). Due to their partial endogenous nature they are easier mitigate than business-related risks. However, a team of experienced IT-experts has to be in place to identify and actively mitigate technology-related DBT risk.

While business strategy-related risks reflect exogenous risk factors, *transformation-related risks* and uncertainties have an internal enterprise focus. In DBT, managing business transformation means anticipating and adapting process designs, organizational structures, incentives and rewards, cultural practices, and the skill-set, attitudes and ultimately the work behavior of employees (Gibson, 2004). Transformation-related risks are based on the required change processes within the organization. A recent study has found that most change-related risks do not lie in strategy development but in execution (Half, 2016). 84% of Digital Transformation programs do not meet their goals, mostly due to people or change management-related issues (Rogers, 2016). Hence, even in case of a promising business strategy and functioning cutting-edge technologies, change projects have a high probability to fail in the execution stage. To mitigate these risks, effective change programs and enterprise-wide communication must lie at the core of DBT execution management.

3. Real Options Model for Valuing Investments in Digital Business Transformation

3.1. Literature Review

The extent of risks and uncertainties surrounding DBT, indicates the need of special treatment of related investments. While there exist vast research papers and best practices on idea generation and digital transformation project management, literature is lacking suitable financial models to support managers in the investment decision process. However, existing literature can provide the building blocks that are necessary to construct such models.

Investment decisions typically share three important characteristics in varying degrees: irreversibility, uncertainty, and timing (Dixit & Pindyck, 1994). Investments in DBT are at least partially, sometimes entirely, irreversible. Additionally, timing of these investments is especially important, as the digital economy is characterized by constant change expressed by rapid technological developments, changing customer needs and frequent market redefinitions. There are several standard investment decision models in Corporate Finance Theory including NPV, IRR, ROI, PI techniques (Copeland & Antikarov, 2001). These methods are very commonly used for technology investments. However, they do not suffice in coping with high levels of uncertainty, as they do not capture managerial flexibility, neither before nor after an investment is made. In general, the higher the uncertainty, the higher the value of managerial flexibility. Hence, traditional methods systematically undervalue projects in situations of high uncertainty (Trigeorgis & Mason, 1987). Especially in the domain of DBT, applying standard valuation methods may lead to wrong investment decisions, i.e. investments that do not maximize shareholder value.

Managerial flexibility can be expressed as the existence of several different Real Options related to leeway during or following investment decisions. Since the 1970s, a large number of papers have addressed the importance of managerial flexibility. Baldwin (1982) examines sequential investment strategies and interdependencies with future investment opportunities. Myers (1984) considers strategic investment opportunities as growth options, while Kester (1984) discusses qualitatively strategic and competitive aspects of growth opportunities. Dixit & Pindyck (1994), Trigeorgis (1988, 1995 and 1996); Sick (1989) and others, discuss many corporate options and provide various expositions of the Real Options approach to investment.

In IS research, several studies propose the use of Real Options Theory for IS/IT investments, with early adopters being Benaroch & Kauffman (1999), Clemons (1991), Dos Santos (1991) and Venkatraman et al. (1993). Over the years and with the growing strategic relevance of IT, literature has provided a variety of models and applications to value managerial flexibility in IS/IT investments. Angelou & Economides (2008) use ROA to prioritize a portfolio of IT projects with interdependencies to follow-up projects of a water supply and sewage company. Balasubramanian et al. (2000) apply the idea of Real Options with the implementation of a document imaging software in a Canadian mortgage bank. Ekström & Björnsson (2005) value the growth option to extend the purchase of an enterprise resource planning software by additional functionalities in the future and Li (2009) values the option to defer an investment in new technologies considering organizational learning. On a more strategic level, Hallikainen et al. (2002) use ROA to assess strategic investments in web content management systems and Angelou & Economides (2009) value a compound real option to strategically evaluate different IT-related business paths. While a large number of papers address the phenomenon on managerial flexibility in strategic IS/IT investment, most research is focusing on valuing investments in single technologies to achieve cost efficiency or productivity improvements. However, to our knowledge, no research exists that investigates or applies Real Options techniques for complex Digital Business Transformation projects.

3.2. *Modeling the Option to Expand*

DBT projects are different from traditional strategic IS/IT projects, as they incorporate a large spectrum of different investment types including different kinds and degrees of risk. Besides traditional IS/IT investments that are necessary, for example, to build infrastructures and met the technical requirements to undergo a DBT, strategic IS/IT investments as well as R&D- and BMI-related investments are required. Furthermore, in order to facilitate a successful transformation, investments in change management initiatives and external consultants will be required. This paper presents a first wholistic approach to value entire DBT projects. The scope of our research is highlighted by the grey area in Figure 4.

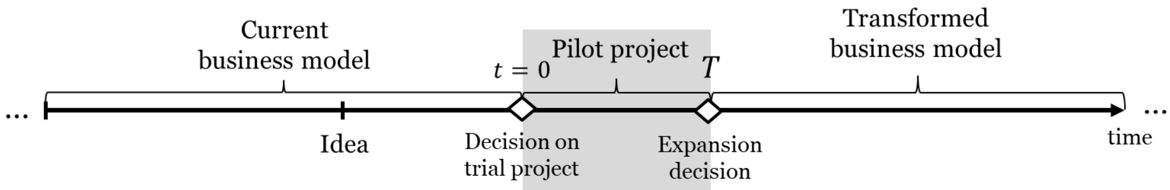

Figure 4: The generic DBT process including a pilot project
(Source: own illustration)

Digital business transformation projects are risky, time-intensive and expensive. In practice, it is a common approach to test risky projects on the real market, before deciding on a large-scale project. Trial projects can resolve uncertainties related to business and technologies and help managers to assess the potentials of a digital transformation project. In this setting, management will be facing two major decisions: (a) whether to launch a trial project and subsequently (b) whether to expand from the trial project into a full transformation project. Hence, the trial project includes an option to expand, which can be added to the value of the trial project in order to rationally justify for its typically negative project returns. In this study, we model the option to expand as a European call option on the project value of the transformation project, which is obtained by investing in the trial project. Furthermore, we show how this option value can shift investment decisions that are based on traditional NPV methods. In the following, we present a simple Real Option pricing model that is able to value the option to expand in the DBT setting. We will present how the Black-Scholes Model (Black & Scholes, 1973) can be applied to value this option. In a second step, we apply the model to a simplified business case of Amazon Go to illustrate the functioning of the model and compare their results to traditional NPV methods. While the Black-Scholes model is subject to strong assumptions, it is widely applied for valuing financial options and real options alike. DBT projects are complex and include several risk factors and types of managerial flexibility.

The presented model views the option to expand as the opportunity to execute a large-scaled digital business transformation project after an initial pilot project has been completed. In order to highlight the value of the managerial flexibility (i.e. the value of the option) that is inherent in a pilot project, the model distinguishes three cases. The first case values the scenario of immediate investment into the full-scaled transformation project without the existence of a prior trial project. The second case uses traditional capital budgeting techniques to value the trial project and the subsequent Digital Transformation project individually. The third case is based on the second case but adds the value of the option to expand, management will obtain by investing in the trial project.

Case I: Application of the NPV method to value the full-scaled transformation project: direct investment in the full Digital Business Transformation project P_{DBT} in $t = 0$. There is no trial project and thus no option to expand into a larger-scaled follow-on project. However, initial R&D expenses cannot be avoided and have to be added to the investment outlays. In this case, the project value equals the expected net present payoffs from P_{DBT}

$$NPV_{DBT} = -I_{DBT} + \sum_{t=0}^{T} \frac{CF_t^{DBT}}{(1+WACC)^t}$$

while CF_t^{DBT} is the full project's expected future cash flows, I_{DBT} its required discounted investment outlays, $WACC$ the company's weighted cost of capital and $T > 0$ the lifetime of the transformation project P_{DBT}.

Case II: Application of the NPV method to value a small-scaled pilot project: investment in a τ-period trial project P_{trial} in $t = 0$ without considering the value of the option to expand. P_{trial} and P_{DBT} are regarded as two dependent investment opportunities. The value of the trial project equals its NPV given as

$$NPV_{trial} = -I_{trial} + \sum_{t=0}^{\tau} \frac{CF_t^{trial}}{(1+WACC)^t}$$

while I_{trial} is the required disounted investment outlays to launch P_{trial}, CF_t^{trial} its expected cash flows, $WACC$ the company's weighted cost of capital, and $\tau > 0$ the lifetime of P_{trial}. Regarding subsequent investment in the full project P_{DBT}, based on the expectations prior to P_{trial}, management will simply receive the sum of the expected net present payoffs from P_{trial} and P_{DBT}

$$NPV_{trial} + NPV_{DBT} = -I_{trial} + \sum_{t=0}^{\tau} \frac{CF_t^{trial}}{(1+WACC)^t} + \left(-\frac{I_{DBT}}{(1+WACC)^\tau} + \sum_{t=\tau}^{\tau+T} \frac{CF_t^{DBT}}{(1+WACC)^t} \right)$$

while I_{DBT} is the required discounted investment outlays to realize P_{DBT}, CF_t^{DBT} its expected cash flows, $WACC$ the company's weighted cost of capital, $\tau > 0$ the lifetime of the trail project and $T > \tau$ the lifetime of the transformation project P_{DBT}.

Case III: Modification of the NPV method from case II by including Real Options Valuation to value the trial project: investment in the trial project in $t = 0$ including the Real Option to expand into the full transformation project in $\tau > 0$ and expansion cost $-I_{DBT}$. The project value amounts to expanded (strategic) NPV $V_0(P_{trial})$ given by

$$V_0(P_{trial}) = -I_{trial} + \sum_{t=0}^{\tau} \frac{CF_t^{trial}}{(1+WACC)^t} + C(P_{DBT}) = NPV_{trial} + C(P_{DBT})$$

while $C(P_{DBT})$ is the call option value to expand into the full-scaled transformation project P_{DBT}, CF_t^{trial} the cash flows from P_{trial}, I_{trial} its investment outlays in $t = 0$, $\tau > 0$ its lifetime and $WACC$ the company's weighted cost of capital. The project timelines from the three different cases are summarized in figure 12.

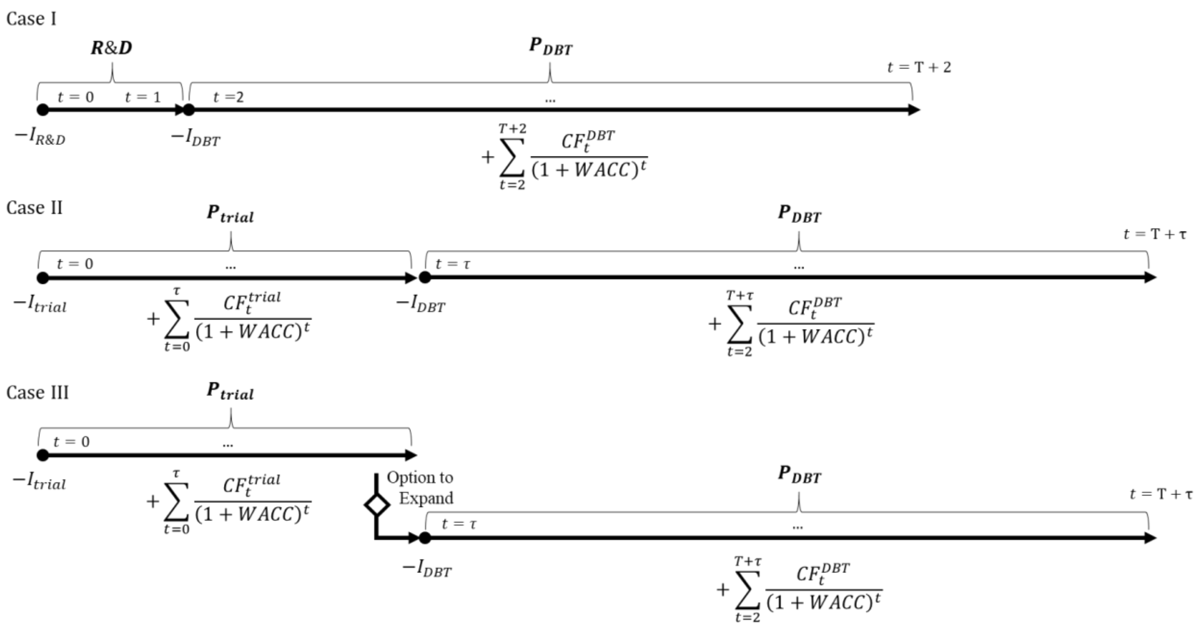

Fig. 5: Case I – III: Project Timelines with and without Option to Expand
(Source: own analysis based on model setup)

Note that R&D expenses might add to I_{DBT} in case I, as it is a prerequisite to launch either of the projects. In case II and III these expenses are included in the investment outlays for the trial project. All three cases enable us to value the projects prior to investment in $t = 0$. The traditional NPV of the trial project NPV_{trial} is given by its cash flows CF_t^{trial} from $0 < t < \tau$ discounted by the WACC and subtracted by the present value of the required investment outlays I_{trial}. In addition to NPV_{trial}, case three enables us to add the value of the call option $C(P_{DBT})$ to subsequently launch the full DBT project P_{DBT}. If the trial project is executed, management will automatically obtain this option. Management will continuously update its expectations on the future cash flows from P_{DBT} based on the learnings from the trial project. After completion of P_{trial} in $t = \tau$, management will face the decision whether to expand into P_{DBT} based on its updated information. In case P_{DBT} is expected to be successful, management will exercise the option to expand and launch P_{DBT}. If P_{DBT} is expected to be unsuccessful, management will not exercise this option and abandon the project realizing the potentially negative NPV from P_{trial} as a sunk cost. The option to expand is thus the right but not the obligation to launch P_{DBT} with exercise price as the cost of expansion I_{DBT} and the option premium being NPV_{trial}. The option value represents the managerial flexibility to expand and has the potential to compensate for a negative NPV from the trial project. If we define the end of P_{trial} in $t = \tau$ as the only point in time at which management can decide on exercising this option (the option's maturity), we can model the option to expand as a European-styled call option with a payoff structure as illustrated in figure 6.

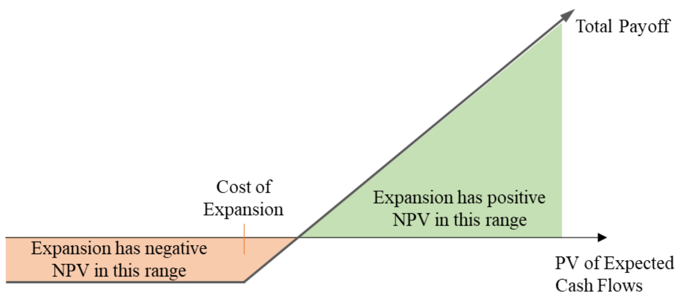

Fig. 6: The Payoff Structure of the Option to Expand in $t = \tau$
(Source: own analysis based on model setup)

At the time of maturity τ (i.e. at the end of the trial project), if the updated expected present value of the cash flows of P_{DBT} is smaller than its cost of expansion I_{CDT}, management will not exercise the option to expand resulting in the (typically negative) payoff of the initial project NPV_{trial} as shown on the left side of the graph of figure 13. In case the developments of the underlying project value expectations are sufficiently positive, management will exercise the option spending I_{DBT} and receiving the additional payoff from P_{DBT} as illustrated on the right side of the payoff function from figure 13.

The option premium paid to acquire the option to expand is the negative NPV from the trial project NPV_{trial}. This kind of managerial flexibility is inherent in the very nature of the P_{trial} and hence automatically obtained by investing into this project. The presented option pricing model is simple, however, it represents a straight-forward approach to showing the significance of Real Option values in risky DBT projects. Due to the model's simplicity, we can apply the Black-Scholes model, which enables us to solve the problem analytically in continuous-time.

Assume the project value of P_{DBT} follows a stochastic process that is defined differential equation

$$dV_t(P_{DBT}) = \mu V_t(P_{DBT})dt + \sigma V_t(P_{DBT})dW$$

where μ is the drift measuring the average growth of $V_t(P_{CDT})$, σ its estimated volatility and dW a normally distributed random variable with mean 0 and standard deviation $\sqrt{dt}$ (i.e. W is a Brownian Motion). The derivation of the solution to the differential equation is mathematically complex, however, applying the formulas provided by Black and Scholes is simple. Note, that the formula is independent of μ as, in the risk-neutral world in the process of deriving the formulas, it is replaced by the risk-free rate r_f. In order to estimate the value of the option at $t = 0$, the Black-Scholes model for a risk-neutral valuation of a European call option can be applied as

$$\boldsymbol{C(V(P_{DBT}), t)} = V(P_{DBT})\Phi(d_1) - I_{DBT}e^{-r(\tau-t)}\Phi(d_2)$$

while

$$d_1 = \frac{\ln(\frac{V(P_{DBT})}{I_{DBT}}) + (r_f + \frac{\sigma^2}{2})(\tau - t)}{\sigma\sqrt{\tau - t}}$$

and

$$d_2 = d_1 - \sigma\sqrt{\tau - t}$$

and

$$\Phi(\mathrm{x}) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} \exp\left\{\frac{-z^2}{2}\right\} dz$$

as the distribution function of the standard normal distribution. The parameter r_f is the risk-free rate, σ the estimated average volatility of the underlying project value $V_t(P_{DBT})$, $\tau - t$ the remaining time to maturity τ at time t and I_{DBT} the cost of expansion. Hence, the value of the option is dependent on five input variables: the project value $V(P_{DBT})$, its volatility σ, the strike price I_{DBT}, the risk-free rate r_f and the life-time of the option τ.

4. Case Study

In this section, I will apply the presented model to the business case of Amazon Go. Additionally, we will pick up the concepts about Digital Transformation from the prior sections and show how they can be interpreted in the context of this real-world business scenario. The presented case is a real business case. However, as Amazon does not disclose their actual financials and expectations for the Amazon Go project, we have to make strong assumptions and apply fictional numbers. With this section, we intend to give evidence to the relevance of the value of Real Options in real-world strategic DBT scenarios and improve understanding of the model's application mechanics for practitioners.

4.1. Building the Business Case

What is Amazon Go?

Amazon.com is a globally diversified digital company with multiple business models. Its success and recent growth is particularly based on several fruitful digital business transformations. Amazon Go is Amazon's newest attempt to accomplish their next DBT. On December 5th 2016, Amazon announced that it was opening an 1,800-square foot, fully digitized grab-and-go convenience store located next to its headquarters in Seattle, Washington, USA. With Amazon Go, the company seeks to create the world's most advanced shopping technology, where the customers never have to wait in line (Amazon, 2016). It is aiming at creating a new customer experience with the potential to disrupt the traditional brick and mortar shopping experience, which is why Amazon Go has drawn the attention of techies, retailers, and consumers alike. To enable their concept, Amazon has developed its *"Just Walk Out Shopping"* experience. Customers simply use their Amazon Go app to enter the store, take the products they want, and leave the store without the need of checking out at a cashier. The system logs the items as the shopper goes along. When customers exit the store through a *"transition area"*, the system senses that they are leaving, adds up the items and charges the shopper's Amazon account (Bishop, 2016). More details on the functioning on the systems can be extracted from figure 7.

Amazon does not publicly state any details about the functioning of the technologies that are installed within the Amazon Go store. However, it is known that Amazon has combined several emerging technologies including computer vision and sensor fusion – a technology bundle that is similar to the solutions installed in modern self-driving vehicles.

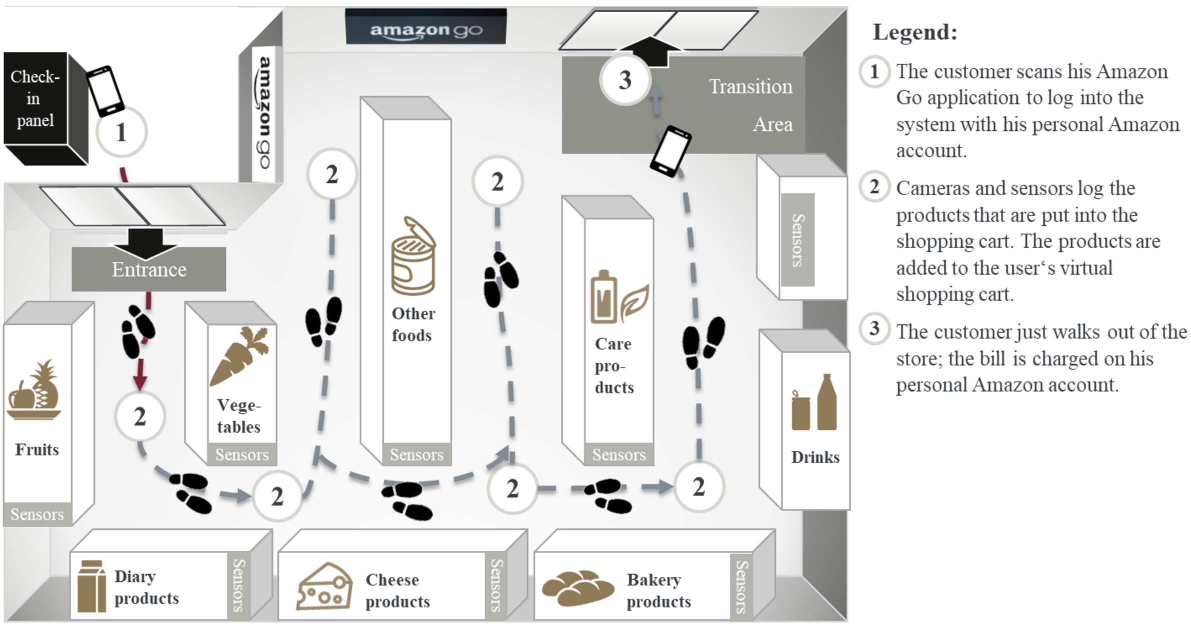

Fig. 7: Exemplary Illustration of an Amazon Go Store
(Source: own illustration of the Amazon Go concept)

Why is Amazon Go a Digital Business Transformation?

The project is directed at entering into the physical grocery retail market with an innovative approach to the concept of supermarkets. Again, details on Amazon's future strategy relating to Amazon Go are not disclosed. However, it can be assumed that, if Amazon expects the concept to have a high profit potential on a larger scale, it will expand its scope by building additional stores in metropolitan areas across the United States. The business model of Amazon Go is enabled by emerging digital technologies, including sensor fusion and tracking technologies as well as platform services and mobile devices. It is a highly strategic initiative that changes the response to the *"what?", "who?", "how?",* and *"why"* questions that define the very components of the business model. More precisely, the case is a business model innovation that expands Amazon's reach into the physical retail market with a value proposition that is based on an entirely new shopping experience. The project can thus be seen as a prime example for a Digital Business Transformation project.

Why do Real Options have to be considered with Amazon Go?

We have learned that all DBT projects should be valued by Real Options analysis. Amazon Go represents a typical case of a DBT. The trial project in Seattle naturally incorporates the option to expand into a large-scaled Amazon Go program. This intuitively adds value to the expected value of the trial project; however, the extra value is not considered by traditional capital budgeting techniques such as NPV methods. Hence, traditional methods would systematically undervalue the Amazon Go pilot project, which might lead to non-optimal investment decisions. As discussed earlier, the size of the option value (and therefore the need of applying ROA) depends on several business scenario-related circumstances:

Uncertainty: the option value is positively correlated with the volatility of the underlying project's future returns. Hence, the higher the uncertainty of future cash flows the larger the value of the option to expand into the full-scaled transformation project and the more urgent the need to modify valuation techniques by including ROA. The different types of risks and uncertainties in DBT projects were presented in section 2.4. The three risk types do also apply to Amazon Go. The business strategy-related risk of Amazon Go is high and refers to the difficulty in anticipating the success of a larger Amazon Go program in the grocery retail market. The installed technologies are expensive and the project only profitable if Amazon can take a fair share of the already satisfied retail-market. It will compete with established supermarket chains such as Wal-Mart, which have been framing the U.S. retail industry for several decades. The new customer experience provided by Amazon Go has the potential to be a game changer, however, it is not clear how popular and affordable this solution is going to be on a large scale.

Additionally, as emerging technologies play a big role in the functioning of Amazon Go, there are several technology-related risks, that might threaten the future success of a large Amazon Go initiative. First, in order to provide a viable solution, the underlying technology has to be 100% reliable. If the sensors misinterpret a shopper's actions, for example by adding articles that are not in his cart or vice versa, the whole idea of Amazon Go has no value. This will be highly influenced by technological progress. As the applied technologies mature, the value of the project is likely increase. Additionally, new technologies could expand the functions to the existing concept, such as the use of digital currencies, big data, or artificial intelligence (e.g. self-refilling shelves). Second, there are severe security issues associated with the *"Just Walk Out Shopping"* technology. If people find a way to trick or hack the system, Amazon might end up sponsoring free grocery shopping tours. Accordingly, people could abuse the fact that the system is entirely automated by immature technologies. In addition to business strategy and technology-related risks, the success in the execution phase of the expansion is threatened by transformation-related uncertainties. In case the larger project is decided, the execution of the transformation bears significant risks. In the case of Amazon, these risks are limited, as Amazon is very experienced with Digital Transformation and dynamically adapting their business to developments of the outside world. Hence, Digital Transformation and change management should count to one of Amazon's core competences. Nevertheless, large change programs always entail new challenges that are hard to foresee. Even in the case of Amazon, this type of uncertainty remains to be a risk factor.

Time horizon of option: the time to maturity of the Real Option is also positively correlated with the option value. This is because the longer the opportunity window to expand into an uncertain transformation project, the more can be observed, which has positive influence on the accuracy of the cash flow expectations. This is the option value that can also be derived from the option to learn. The longer the new business model is tested, the more it management will learn about the project's value behavior, which can be viewed as a hedge against the downside potential of the inherent uncertainties. In the case of Amazon Go, the lifetime of the option is defined by the lifetime of the trial project. We assume, after the store in Seattle has sufficiently indicated the success potential of the full project, management will have to decide whether to expand or not.

Time horizon of project: the longer the time horizon of the follow-on project, the higher its uncertainty. While it might be possible to estimate the cash flows from the first periods of the project lifetime, finding accurate estimates for project returns that lie far in the future is extremely difficult. In the model, this is implied by the growing effect of the volatility on the estimates of cash flows at later points in time. With increasing lifetime of the project, uncertainty about the accuracy of the estimates grows. BMI projects such as Amazon Go typically have a strategic time horizon.

Nature of the resulting competitive advantage: the nature of the competitive advantage resulting from the DBT has two different dimensions to it: the exclusivity of the right to invest in the follow-on project and the sustainability of the competitive advantage when management decides to invest into the full-scaled program. Amazon's exclusive right to invest in the full-scaled program, is based on the unique technologies and concepts that were self-developed by Amazon. No competitors have access to the information that is necessary to imitate the follow-on project. This is one of the reasons why Amazon keeps detailed information about the functioning of their system top secret. The sustainability of the competitive advantage resulting from a potential full-scaled project is closely related to this exclusive right. It is about the length of the time horizon in which Amazon can prevent competitors to copy their concept and enter into the market. Due to the complexity and the utmost discretion around Amazon Go, it can be expected that imitability is low and substitutability is high. Hence, the competitive advantage that would result from a successful follow-on project can be seen as sustainable, which has a positive effect on the size of the option value.

How can the ROA model be applied to the case of Amazon Go?

In practice, many DBT projects are based on a pilot project to increase management's knowledge and improve the accuracy of expectations before investing large amounts of money into a project with a highly uncertain payoff structure. This is also the case with Amazon Go. The presented model provides a blueprint for the application of Real Options valuation to these kinds of DBT projects. The pilot store of Amazon Go in Seattle incorporates the option to expand into a larger program. The value of the option should be high as uncertainty is high, the projects lifetime long and competitive advantage sustainable. The underlying of the option is the project value of the follow-on project that is defined by its expected future cash flows and their volatility. The exercise price of the option is the present value of the investment outlays that are required to build and maintain the additional stores from the full-scaled project. We assume that the costs of both projects are fixed and known by Amazon and the future cash flows of the full project follow a geometric Brownian motion. The investment decision and the valuation of the trial project are made before the trial project is launched. The time to maturity of the option is the lifetime of the pilot Amazon Go store. During this time, Amazon will continuously update its knowledge on the profit potential of the follow-on project based on the learnings from the test store. At the end of its lifetime, Amazon has to decide whether to build the additional stores or abandon the project as a whole. If the trial store was a success, Amazon will decide to expand. Otherwise, Amazon will not exercise the option and realize the (negative) payoffs from the trial project to mitigate the damages.

Applying the model as described above, in a first step the trial project as well as the transformation project will be valued in $t = 0$ by applying traditional NPV methods. In a second step, we include the option to expand based on the Black-Scholes model. The volatility of the transformation project's returns will be estimated based on the average volatility of a mix of historical data from Amazon's stock returns and the stock returns from peer companies such as eBay, Google, PayPal and Apple as well as the stock returns from large supermarket and convenience store chains such as Wal-Mart. Both results will be compared with each other to show the effect of the option value on the solution to the underlying capital budgeting problem. The option value is always positive as it describes the managerial flexibility that is included in the very nature of the pilot project. Without the option value, a trial project will typically have a negative NPV resulting in a no-investment decision. The option to expand thus modifies the traditional NPV of the trial store bearing the potential to turn a traditionally unprofitable project into a profitable project. The option value does not necessarily have an impact on the investment decision. However, if the value of the option is sufficiently large, there might be a shift in management's decision making.

4.2. Parametrization

In order to calculate the results from the model's three cases for Amazon Go, several input variables are required. Some of the variables have to be estimated, others can be directly derived from the setting of the case. In the following, I will briefly describe how we obtained the variables for the case of Amazon Go. (Table with input variables)

In order to apply the full model, the numbers for the following parameters have to be obtained:

a) the time horizon of the pilot project τ, i.e. the time to maturity of the option to expand,
b) the cost I_{trial} and payoff structure CF_t^{trial} of the pilot project in Seattle,
c) the cost of expansion I_{DBT}, i.e. the present value of the costs associated with establishing and maintaining the additional stores and their infrastructure from the full project,
d) the time horizon T of the full project and its expected future cash flows CF_t^{DBT},
e) Amazon's weighted average cost of capital (WACC) for discounting future cash flows and expenses,
f) the estimated volatility σ of the future project returns from the full project P_{DBT} and,
g) the risk-free rate r_f used to value the option to expand.

While Amazon does not disclose any financial data on their project, in the following, we present our approach to estimating the required variables.

a) Time horizon of pilot project τ

The time horizon of the pilot project for Amazon Go includes the research and development phase prior to opening the store. I assume that Amazon has spent around two years to develop, install and test the applied technologies. In the second phase of the trial project, a pilot store is opened. During this period, the store is only accessible for Amazon's employees. It is expected that the store will be opened to public soon, which is why I assume that this second phase lasts one year. The third and final phase of the pilot project the trial store it is tested with the open public. We can expect that another two years will pass, before Amazon further announces its intentions with the Amazon Go program. This results in a total lifetime of *five years* ($\tau = 5$) – two years of R&D plus a one-year employee test phase plus a two-year public test phase. Hence, the lifetime of the option to expand is expected to be about five years. We further assume that Amazon has set itself an internal deadline about the decision to expand at the end of this lifetime. There is thus no possibility of early exercise or deferring the expansion decision.

b) Investment outlays I_{trial} and cash flows CF_t^{trial} from the pilot project

To obtain I_{trial}, the costs to develop the technologies and establish and maintain the pilot store in Seattle have to be summed up and discounted to $t = 0$. As we do not know the exact amount Amazon is spending here, I have to make some assumptions and approximate this number. The size of the store is 1,800 square foot. Major cost drivers are the R&D expenses for the technologies, the monthly rent for the real estate, the employees' monthly salaries, the interior of the store (shelves, refrigerators etc.), and the acquisition of the articles that are being sold. We will further assume that the ramp-up as well as the maintenance costs for the additional stores are fixed and known and equal the costs of the trial store excluding the nonrecurring initial R&D expenses. To keep it simple, instead of providing systematic estimates for the single cost factors, we will assume that Amazon has to invest the following expenses:

- 250 million USD p.a. during the two-year R&D phase in $t = 0$ and $t = 1$;
- 200 million USD ramp-up costs for building the store in $t = 2$;
- 100 million USD p.a. to maintain the store and repurchase sold products from $t = 2$ to $t = 4$;

The net present value of these numbers amounts to the investment outlays of the trial project I_{trial}.

Regarding the cash flows from the trial project CF_t^{trial}, we can assume that their size will be rather small. The Amazon Go pilot project has three different phases. During the R&D period, Amazon will not receive any cash flows. In the second phase, which is currently ongoing, the Amazon Go store is only open to Amazon's employees. Hence, the cash flows from this phase will be limited. We assume that this number is not able to fully cover the cost of maintenance and product repurchasing in this year. Amazon will be receiving *80 million USD* in that year. In the third phase, the store will be open to public for two years. We assume that the revenues will increase to 120 million USD p.a., exceeding the annual cost of maintenance.

c) Cost of expansion I_{DBT}

The cost of expansion is the net present sum of all expenses related with opening and maintaining the stores that are part of the full transformation project P_{DBT}. Even though Amazon has not publicly stated its strategies for a potential follow-on project, I assume that, in the first step, Amazon will open several stores in large metropolitan areas across the United States. According to recent estimates, there are ten cities in the US with a population larger than one million inhabitants (Seattle not being among them). We assume that Amazon will open one store in each of these cities if it decides to expand into the transformation project. The cost of expansion will then equal the net present value of ten times the ramp-up cost of *200 million USD* to build the stores plus ten times the annual cost of maintenance of *100 million USD* over the lifetime of the transformation project. This adds up to *2 billion USD* initial ramp-up costs, plus an annual amount of *1 billion USD* to maintain the stores. The net present value of these numbers amounts to the cost of expansion I_{DBT}.

d) Cash flows from the full-scaled project CF_t^{DBT} and its time horizon T

Similar to the public test phase of the store in Seattle, I assume that Amazon Go stores will generate *120 million USD* in revenues each year with every additional store. I further assume a growth rate of 2% p.a. in revenues, which is partly based on the growth of the US retail market and partly on Amazon's expectations to gain popularity over time, as technology matures and the brand name establishes. The expected cash flows from a DBT project such as a large Amazon Go program are highly risky. The uncertainties that are related to this value is expressed by their volatility σ, which is one of the critical input factors to find the value of the option to expand. By summing up the annual revenues from the ten new stores from the full project plus the coexisting trial store, we arrive at *1.327 billion USD* in the first year *1.353 billion USD* in the second year *1.380 billion USD* in the third year and so on. The lifetime of the stores from the transformation project T until the stores have to be closed or renewed is assumed to amount *ten years*. Hence, in case of expansion, the trial store will reach its lifetime in $t = 11$, as it was launched three years prior to the stores from the transformation project.

e) The weighted average cost of capital (WACC)

The weighted average cost of capital is the interest rate a company has to pay on its employed capital. It is a mix of the interest paid on equity and the interest paid on debt weighted with the company's debt to equity ratio. All sources of capital, including common stock, preferred stock, bonds and any other long-term debt, are included in a WACC calculation. A firm's WACC increases as the beta and rate of return on equity increase, as an increase in WACC denotes a decrease in valuation and an increase in risk (Investopedia, 2017). The formula to calculate the WACC is given by $WACC = \frac{Equity}{Debt} * r_E + \frac{Debt}{Equity} * r_D * (1 - T_c)$, while r_E is the cost of equity, r_D the cost of debt and T_c the company's tax rate. To calculate the WACC for Amazon, we used numbers retrieved via S&P Capital IQ. The resulting WACC amounts 6.3%. We will use this rate to discount future cash flows and expenses, which is the standard approach to calculate present values in Corporate Finance Theory as well as in practical financial modelling applications.

f) Estimated volatility σ of future project returns

There are several approaches to estimate the volatility of future returns.[3] We use a simplified approach that is frequently applied in practice. The volatility will be estimated based on the historic asset returns of the stocks of Amazon and nine other peer companies. The peer companies are divided in two groups. The first group consists of established digital innovators and internet companies, namely Amazon, Apple, Google, eBay and PayPal. The second group represents the physical retail market in the U.S., including large supermarket chains such as Wal-Mart, the Target Corporation and Carrefour as well as the largest convenience store holdings in the U.S., namely Couche-Tard and Seven & i Holdings. To estimate their future volatilities, we calculate the daily log returns across a one-year time window. In a second step, we compute the daily variance of these returns and calculate their average. By taking the square root of the average variance, we receive the average daily standard deviation, i.e. the average volatility of the asset returns. Finally, I will annualize these numbers by multiplying them with $\sqrt{250}$, while 250 represents an approximation to the annual number of trading days. The results from these calculations are listed in table 1.

[3] A sophisticated way of estimating future volatilities provided by the Monte Carlo Simulation. However, as this study places its focus on the valuation of Real Options in the context of DBT, we stick with a simpler approach that is also frequently applied in financial modelling practice.

	Annualized volatility	Weights
Peer Group 1 - Digital Innovators & Internet Companies		
Amazon	19.20%	10%
Apple	17.91%	10%
Google	15.64%	10%
eBay	22.26%	10%
PayPal	21.56%	10%
Average Peer Group 1	19.31%	50%
Peer Group 2 - Retailers & Convenience Stores		
Carrefour	18.85%	10%
Couche-Tard	20.22%	10%
Wal-Mart	15.38%	10%
Target Corp	25.84%	10%
Seven & i Holdings	20.42%	10%
Average Peer Group 2	20.14%	50%
Gross total average	19.73%	100%

Tab. 1: Volatility Estimations of Peer Companies
(Source: own calculations based on data provided by S&P Capital IQ)

As illustrated in table 1, the volatility of Amazon Go is estimated to be the arithmetic average of all volatilities from the peer companies. In the calculations for this volatility, the estimated volatilities of the peer companies are assigned equal weights. This results in a gross total average annual volatility of $\sigma = 0.1973$, i.e. roughly 20%.

g) Risk-free rate r_f

The Black-Scholes model provides a framework for finding the value of options in a risk-neutral world. We need the risk-free interest rate r_f to compute these calculations. In practice, the risk-free interest rate is typically derived from the returns of the government treasury bond in the respective market with a lifetime that is symmetric to the lifetime of the underlying project. Hence, in our case, we can use the rate of the 10-year U.S. treasury bond to represent the risk-free rate. Again, we estimate the future rate using a historic one-year time window and compute the average. During the regarded time period, the average rate was 2.19%. We will use this number as the risk-free rate in our real option valuation model. Note that, while the gross project value of the underlying and its volatility can have a large impact on the option value, the influence of the risk-free rate is rather limited.

4.3. Traditional Valuation Techniques

In our model, case I and case II apply traditional NPV techniques to calculate the present values of the two projects. Case I values only the transformation project with direct investments in $t = 0$. However, an initial two-period R&D phase is a prerequisite for all cases. Case II values the scenario, in which the pilot project and subsequently the transformation project is executed. In this case, the R&D phase will become part of the trail project. It treats both investments as dependent projects, while the transformation project is executed after the end of the trial project in $t = 5$.

Case I

The present value of the expenses from the first case consist of R&D expenses in $t = 0$ and $t = 1$, subsequent ramp-up costs for ten stores in $t = 2$ and annual maintenance and repurchasing costs for the following period of ten years. The present value of the sum of these expenses I_{DBT} equals *9,081.67 million USD*. After the R&D phase, Amazon will receive cash flows from the sales of the ten stores. These cash flows will grow by 2% annually. The present value of the sum of these cash flows amounts *8,881.08 million USD*. Hence, the net present value in case of direct investment in the transformation project is 8,881.08 – 9,081.67 = *-200.58 million USD*. As this is smaller than zero, direct investment in P_{DBT} is not profitable leading to a no-investment decision for Amazon Go.

Case II

Case II values the trial project and the subsequent transformation project as two dependent projects. There is no option to expand and Amazon thus has to decide on the full program including both projects in $t = 0$. The sum of both net present values is the expected gross net present value of the combined project. The investment outlays for the trial project consist of the two-period R&D expenses, the ramp-up cost for the trial store as well as the three-year maintenance cost during the test phase. The present value of the sum of these expenses I_{trial} amounts to *912.25 million USD.* The cash flows from the trial project are small. Again, during the R&D phase, no cash flows will be generated. In the first year, where the trial store is only open to Amazon's employees, Amazon will generate *80 million USD* in sales. In the following two periods, the store will be open to public, resulting in two times *120 million USD.* The resulting present value of cash flows amounts to *264.68 million USD.* The resulting net present value equals 264.68 – 912.25 = *-647.56 million USD.* Again, this will leave Amazon with a negative net present value resulting in a no-investment decision for the trial project.

The subsequent transformation project starts in $t = 5$. Ten additional stores will be created resulting in expenses analogously to case I. The only difference is the coexistence of the trial store until $t = 11$ and the delay due to the prior trial project. The present value of the expenses from the transformation project (in $t = 0$) amounts *7,589.42 million USD*. The present value of the cash flows that are generated during the project's lifetime of ten years amounts *7,848.33 million USD*. In the transformation project, the net present value thus equals 7,848.33 – 7,589.42 = *256.91 million USD*. This value is positive, however, in order to receive this amount, Amazon first has to invest into the trial project with a negative net present value of -647.56 million USD. Hence, the gross net present value from the full program amounts -647.56 + 256.91 = -390.65 *million USD*. The full program is thus unprofitable and Amazon would not decide to invest in the first place.

4.4. The Value of the Option to Expand

In case III, the value of the Real Option to expand into the risky transformation project will be calculated and added to the net present value of the trial project. The basic setting and the cash flow structures are the same as in the second case, however, Amazon will automatically obtain the option to expand into the transformation project when investing into the trial project. Again, the net present value of the trial project excluding the option value equals -647.56 million USD and the net present value of the transformation project amounts 256.91 million USD. The value of the option in $t = 0$ is estimated by applying the Black-Scholes model as described above. The value of the option amounts to *1,821.94 million USD*. The large size of this value can be explained by the high volatility of the transformation project's cash flows (~20%) and the significant lifetime of the option ($\tau = 5$ years). Adding this amount to the NPV of the trial project leaves us with the *extended strategic NPV* of P_{trial} equaling -647.56 + 1,821.94 = *1,174.37 million USD*. The trial project has thus become profitable. The gross net present value of both projects then amounts to 1,174.37 + 256.91 = *1,431.29 billion USD*.

Thus, including the option to expand results in a substantially positive NPV for the trial project as well as the full program. In this case, Amazon would decide to invest in the trial project in $t = 0$. In $t = \tau$, Amazon will face the decision whether to expand into the full project based on its learnings and the resulting updated project cash flow expectations of P_{DBT}.

4.5. Summary and Discussions

The results from the calculations of the three cases are summarized in table 2. Case I and II show the results from traditional NPV techniques both resulting in non-optimal investment decisions. In case III, the value of the option to expand compensates for the negative net present value of the trial project leading to a shift in Amazon's investment decision. The high value of the option is particularly explained by the high volatility (~20%) of the expected future project returns, which reflects the high uncertainties that are typical for DBT projects. It describes the upside as well as downside potential of the movements of the DBT project value across time. In $t = 5$ Amazon has to decide on whether to exercise the option to expand or not. Until then, Amazon will update its expectations on the future profit potential from the transformation project based on the learnings from the trial project. In case the updated expected cash flows of P_{DBT} will exceed its investment outlays I_{DBT} Amazon will decide to expand. If the updated expected cash flows are lower than the exercise price I_{DBT} Amazon will decide to abandon the project. If no Real Options approach is applied, the trial project is heavily undervalued, which would lead to a non-optimal investment decision and the loss of extensive profit potential.

Case I		*in USD mm*
P_{CDT}	PV expenses	9.081,67
	PV cash flows	8.881,08
	NPV Project	**(200,58)**
	Investment decision	**no**

Case II		*in USD mm*
P_{trial}	PV expenses trial project	912,25
	PV cash flows trial project	264,68
	NPV trial project	(647,56)
P_{CDT}	PV expenses CDT project	7.589,42
	PV cash flows CDT project	7.846,33
	NPV CDT project	256,91
	Combined NPV	**(390,65)**
	Investment decision	**no**

Case III		*in USD mm*
P_{trial}	PV expenses trial project	912,25
	PV cash flows trial project	264,68
	NPV trial project	(647,56)
	Option value	**1.821,94**
	Extended strategic NPV trial proje	**1.174,37**
P_{CDT}	PV expenses CDT project	7.589,42
	PV cash flows CDT project	7.846,33
	NPV CDT project	256,91
	Combined NPV	**1.431,29**
	Investment decision	**yes**

Tab. 2: Summary of Results – Case I – III
(Source: own calculations from the Amazon Go business case)

The case of Amazon Go is a simple example that is able to give evidence to the existence of the large value of managerial flexibility in risky DBT projects. It proves that even by only including a single option and a single source of uncertainty, it is inevitable to modify traditional capital budgeting techniques when valuing Digital Business Transformation projects. The value of the option to expand will always be positive. However, the size of the option value will strongly vary with changing input variables from different project settings. Hence, we cannot make a general statement about the potential of Real Options to change investment decisions. This has to be evaluated for every case individually. In business cases with lower volatility, shorter option lifetimes, larger expenses or smaller cash flows, the option value might not be sufficient to shift management's investment decisions. However, the nature of DBT projects typically favors a high option value and thus the necessity to apply ROA. The presented case makes strong assumptions about the input variables and the numbers that are used in the financial model. However, these numbers can be easily updated and modified. In real-life scenarios, management will not have any difficulties to feed the model with more accurate estimates, as it typically has access to comprehensive data sets about the company and its investment opportunities.

5. Conclusions

While Digital Transformations can occur on every layer in the business architecture, a digital business transformation refers to a transformational change in the business model driven by digital technologies. DBT projects are subject to extensive uncertainties that imply the need to adjust traditional capital budgeting techniques in context DBT investments. The simple Real Options valuation model presented by this paper can easily be applied to value DBT projects. It shows how traditional NPV methods can be extended to include the value of the option to expand. In the final section of this paper, the presented model was applied to the real-world business case of Amazon Go. We found that the option to expand has the potential to change strategic investment decisions for risky DBT projects. The option value in DBT projects are particularly large, as these projects typically have a long time-horizon with high uncertainties. This is expressed by the high volatility of the expected future cash flows that can be generated by DBT. The results from the Amazon Go case underlined the importance of modifying traditional capital budgeting techniques for DBT.

We can expect that the area of DBT will grow in importance as emergent technologies mature and the economy further digitalizes. Exponential technological growth motivates the necessity to revise traditional capital budgeting techniques. New methods should be developed, which will require comprehensive cross-functional skills and experts on Digital Transformation as well as Real Options Analysis. The presented study serves as an introduction to Real Options Analysis in the context of Digital Business Transformation. It highlights the importance of the intersection of these two areas and lays the foundations for future research. Future research should engage in the following to further develop our knowledge in this new area:

- apply empirical studies to further investigate practical implications of the changing role of digital
- in the business domain;
- apply empirical studies to study the nature of digital business transformation and its financial as well as non-financial implications;
- apply empirical studies to learn more about the strategic decision processes that are currently used by companies that are confronted with deciding on Digital Business Transformation projects;
- develop more sophisticated Real Options valuation models, that provide more realistic estimations for complex real-life DBT projects including several interacting Real Options, early exercise, several starting points, cost uncertainty or dividend payments;
- apply Real Options Analysis to real-world scenarios other than the case of Amazon Go;
- include game theoretic models to include strategic competitive actions in cash flow estimation and project valuation;
- collect meta-data, which allows potential users of Real Options Analysis to make sounder predictions about the consequences of their decisions, based on a larger pool of documented experiences with the implementation of ideas set out in this thesis.

The presented thesis opens a new chapter of research at the interface between Information Systems and Real Options Theory and lays the foundations for future studies on this area. It provides a set of simple frameworks that can serve to increase the general understanding of Digital Transformation by researchers and practitioners and revises traditional capital budgeting techniques in the context of DBT.

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