The development paths and relationships of value creation and capture: an investigation of digital ventures using System Dynamics

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Copyright statement

"The overwhelming importance of future profits is counterintuitive even in Silicon Valley. For a company to be valuable it must grow *and endure*, but many entrepreneurs focus only on short-term growth. They have an excuse: growth is easy to measure, but durability isn't. Those who succumb to measurement mania obsess about weekly active user statistics, monthly revenue targets, and quarterly earnings reports. However, you can hit those numbers and still overlook deeper, harder-to-measure problems that threaten the durability of your business.

[...]

If you focus on near-term growth above all else, you miss the most important question you should be asking: *will this business still be around a decade from now?* Numbers alone won't tell you the answer; instead you must think critically about the qualitative characteristics of your business."

(Thiel and Masters, 2014, p. 47)

Abstract

Purpose: While many digital ventures strive for high growth, they may neglect developing an ability to capture value, causing their failure or dependence on investors' funding. Therefore, this thesis aims to develop an understanding of the requirements and priorities allowing digital ventures to develop an ability to capture value while growing their value creation. It investigates how digital ventures' growth in value creation and ability to capture value develop over time and the relationships between these two performance outcomes.

Methods: This thesis develops a System Dynamics model to represent the complex system and processes that affect value creation and capture. The basis for this model is the synthesis of two contemporary growth process theories – growth paths theory and dynamic states theory – and their adaptation for the context of digital ventures. The model is validated using secondary data from four case studies. It simulates scenarios to identify development patterns and relationships of value creation and capture.

Findings: By synthesising growth paths and dynamic states theory, this thesis reveals the dynamic relationships between performance outcomes, resources, and capabilities. These elements change continuously through the feedback loops connecting them. It also identifies the influence of discontinuous changes in contextual variables regarding a venture's environment, business model design, capability development, and dominant logic on those feedback loops. The scenario simulations reveal two development patterns that depend on a venture's dominant logic. Ventures unwilling to increase their employee numbers exhibit goal-seeking development towards natural levels of value creation and capture. The trajectories and levels towards which ventures develop depend on the contextual factors. Ventures willing to grow by hiring more employees experience exponential growth in value creation. They develop towards a lower ability to capture value in a goal-seeking manner, pointing to adverse effects of growth on the ability to capture value during growth periods. When ventures begin to exploit their established size rather than growing aggressively, economies of scale improve their ability to capture value, highlighting a beneficial relationship between growth in value creation and value capture after periods of growth.

Implications: Conflicting with the common belief among digital entrepreneurs, this thesis indicates that growth has only minor positive effects on capturing value. Instead of trying to grow themselves profitable, digital ventures need to ensure that their conceptual factors allow them to develop an ability to capture value. They need to select an appropriate environment and business model before growing. They should also pursue continuous improvements to raise their natural performance levels. These two elements are required to create the conditions to grow value creation and develop an ability to capture value. Digital ventures may need to change their priorities. They may pursue lower growth rates to maintain their ability to capture value or obtain funding to sustain high-growth periods. Moreover, digital ventures also need to consider exploiting their established size rather than pursuing further growth.

Contribution: This thesis provides a comprehensive formal growth process theory for digital ventures focussing on two performance outcomes. It provides an overview of the complex system and processes driving value creation and capture using a System Dynamics model. It illustrates possible development paths of value creation and capture and their relationships for digital ventures, contributing to unsettled questions in the performance management literature and challenging digital entrepreneurs' beliefs. Those practitioners can use the model to approximate the development of their ventures, and researchers can adapt it to investigate growth and performance in non-digital companies.

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List of selected publications

Journal articles related to this thesis

- Lycko, M.A. and Mahlendorf, M.D., 2017. Management-Control-Systeme in Start-ups. *Controlling & Management Review*, *61*(6), pp.24-33.

Conference proceedings extracted from this thesis

- [1]Lycko, M.A., Galanakis, K. and Valeo-Silva, N., 2021. The Performance Development of Software-as-a-Service Ventures. In: *Proceedings of the 23rd UK System Dynamics Chapter Annual Conference 'Thinking Big'*, 25-26 May 2021.
- Lycko, M.A., Galanakis, K. and Valero-Silva, N., 2019. Strategic entrepreneurship for digital start-ups: Factors affecting exploration and exploitation along the growth process. In: 11th *International Process Symposium (PROS2019),* Crete, 19-22 June 2019.
- Lycko, M.A., Galanakis, K. and Valero-Silva, N., 2018. Achieving growth by forming stakeholder relationships: an exploration of strategies for digital start-ups. In: *British Academy of Management (BAM2018) Conference*, Bristol Business School, University of the West of England, Bristol, 4-6 September 2018.
- [2]Lycko, M.A., 2018. Achieving growth by forming stakeholder relationships: an exploration of strategies for digital start-ups. In: *British BAM2018 Doctoral Symposium*, Bristol Business School, University of the West of England, Bristol, 4-6 September 2018.

Awards

1. Runner up for the Student Prize at the 23rd UK System Dynamics Chapter Annual Conference
2. Awarded best poster presentation at the BAM2018 Doctoral Symposium

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List of abbreviations

CA	Complementary assets
Eq	Equation
FM	Firm managing/Firm management
FT	Financial Times
i.e.	That is
IPO	Initial public offering
MS	Marketing and selling/marketing and sales
OLC	Organisational life-cycle theory
SaaS	Software-as-a-service
TD	Technology developing/technology development
VD	Value delivering
WoM	Word-of-mouth

Chapter 1: Introduction

The development of digital technologies and the rapid growth of the digital economy have led to the emergence and success of digital businesses as a new type of company (Hafezieh, Akhavan and Eshraghian, 2011). Digital ventures are young companies that use digital technologies as a central part of their business model (Kraus *et al.*, 2018; Nzembayie, Buckley and Cooney, 2019; Zaheer, Breyer and Dumay, 2019). They commercialise the internet and information and communication technology (Kraus *et al.*, 2018). Examples of such technologies include artefacts such as software or an app, platforms such as social networks, or infrastructure like cloud computing (Nambisan, 2017).

While some digital ventures have achieved incredible success, many others have failed (Zaheer *et al.*, 2019). In theory, digital ventures have a high growth potential due to their scalability, market demand, and access to resources (Kollmann *et al.*, 2016; Zaheer *et al.*, 2019). However, only 52 per cent of digital ventures reach the age of three years (Hathaway, 2013). Compared to the 59 per cent of all companies that survive their first three years (Stangler, 2010), digital ventures thus fail quicker and more often. Therefore, investigating and explaining the performance of digital ventures remains a critical research topic to improve their survival rates (Kraus *et al.*, 2018; Zaheer *et al.*, 2019; Zaheer, Breyer and Dumay, 2019).

This thesis investigates the performance developments and relationships of digital ventures. Thereby, it contributes to existing theory by exploring performance development patterns and the relationship between critical performance measures. It illustrates possible performance trajectories and the impact of growth for the benefit of digital managers and entrepreneurs, who may use this information to improve the survival and viability of their ventures. From a theoretical perspective, this thesis pursues these goals by integrating and formalising two complementary growth process theories: growth paths theory (Garnsey, 1998) and dynamic states theory (Levie and Lichtenstein, 2010). They describe the development and performance of companies over time (Davidsson, Achtenhagen and Naldi, 2010). This thesis contextualises these two theories using the emerging literature on digital ventures to apply these general theories to the specific context.

The sections below outline the literature on digital business ventures, identify current research questions regarding their performance, present growth process theories as a conceptual basis to investigate these questions, and outline the approach taken in this thesis to answer them.

1.1. Digital ventures

Digital ventures face unique challenges and opportunities because of digital products and services' unique characteristics compared to physical ones (Hull *et al.*, 2007; Kraus *et al.*, 2018; Zaheer *et al.*, 2019). These differences include the range of market opportunities, ease of market entry, pursuit of growth, competitive threats, and need to innovate continuously. The digital economy continues to develop, and new technologies emerge to address changing customer needs. Therefore, digital ventures can pursue a vast amount of growth opportunities (Kraus *et al.*, 2018). Digital ventures can also establish their technologies at significantly lower costs than physical products. Thus, entering a market to pursue opportunities is much easier for digital companies (Kraus *et al.*, 2018). Due to these opportunities and the ease to pursue them, digital ventures are noted for their growth potential (Zhang, Lichtenstein and Gander, 2015; Täuscher and Abdelkafi, 2018; Huang, Henfridsson and Liu, 2021). Such growth may also make digital ventures' products more attractive depending on their business model design due to, for example, network effects (Amit and Zott, 2001; Huang *et al.*, 2017). However, these advantages also apply to competitors and new entrants. Therefore, digital ventures may struggle to sustain a competitive advantage and an ability to capture value (Steininger, Wunderlich and Pohl, 2013). Moreover, intellectual property rights for digital technologies are weak. While copyrights protect software, competitors can replicate software products with different software code. Digital ventures thus need to continuously improve their technology to stay ahead of competitors (Nambisan, 2017; Kraus *et al.*, 2018; Zaheer, Breyer and Dumay, 2019). Digital technologies allow doing so by remaining modular, reprogrammable, and editable even after selling them and scaling them up on the market (Nambisan, 2017).

These unique opportunities and challenges have distinct effects on a digital venture's success, which requires further investigation (Kraus et al., 2018; Zaheer et al., 2019; Zaheer, Breyer and Dumay, 2019). For example, different opportunities may be differently attractive and require careful selection and continuous adaptation by managers and entrepreneurs of digital ventures (Ries, 2011; Ojala, 2016). The ease and need to grow may entice them to scale up prematurely and pressure their resources (Marmer *et al.*, 2011). Continuous competitive threats may reduce growth and profitability (Teece, 2018). Thus, "a prominent research theme within digital entrepreneurship that needs to be investigated is digital start-up performance" (Zaheer et al., 2019, p. 263).

1.2. Performance outcomes and identification of research questions

Two critical performance measures for all companies, including digital ventures, are their growth in value creation and their ability to capture value (Hull *et al.*, 2007; Huang *et al.*, 2017; Hsieh and Wu, 2019). Value creation refers to a venture's generation of benefit for its customers. Customers assess the value of the venture's product subjectively based on its attributes, and their needs and circumstances. This value can be expressed in monetary terms through customers' willingness to pay for the product if there is a single source of supply (Brandenburger and Stuart, 1996; Bowman and Ambrosini, 2000; Bowman and Ambrosini, 2010). For example, an individual customer may determine the value of a product by specifying the amount he is willing to pay based on the product's performance, taste, or colour (Bowman and Ambrosini, 2000). On a company level, value creation thus refers to the sum of value created for all individual customers that bought a product or service in a period (Lepak, Smith and Taylor, 2007). The captured value represents the share of the created value received from customers and maintained by the venture as profit. The amount of value captured is equal or smaller than the amount of value created. Firstly, the revenue received from customers is usually lower than their willingness to pay due to competition. Secondly, companies incur the costs for suppliers and employees that help them create customer value. Whereas customers benefit from value creation, the venture benefits from capturing value as it increases the company's resources (Brandenburger and Stuart, 1996; Lepak, Smith and Taylor, 2007; Bowman and Ambrosini, 2000; Bowman and Ambrosini, 2010). Whereas growth in value creation increases the maximum amount of value that could be captured by the venture, the ability to capture value specifies the portion of that value that the firm actually captures.

Performing well across both outcomes is critical for digital ventures. Firstly, value creation determines the potential for value capture. Therefore, growing the amount of created value is the essence of entrepreneurship, and ambitious entrepreneurs should strive to maximise the value they create for their customers (Hull *et al.*, 2007; Hermans *et al.*, 2012). The resources generated through the company's value creation and ability to capture value provide reserves and the means for reinvestments. Thus, companies should maximise the share of the value they capture (Sirmon and Hitt, 2003; Garnsey, Dee and Ford, 2006; Ketchen, Ireland and Snow, 2007). Together, the growth in value creation and the ability to capture value are holistic performance outcomes for companies. Therefore, they are considered the critical outcomes of business models, entrepreneurial activity, and strategic decision-making(Bowman and Ambrosini, 2000; Amit and Zott, 2001; Zott and Amit, 2007; Steffens, Davidsson and Fitzsimmons, 2009; Zott, Amit and Massa, 2011; Steininger, 2019).

However, some digital ventures may focus on growing their value creation without developing an ability to capture value. For example, digital entrepreneurs may focus on scaling up their customer and user base because they "typically face significant growth expectations" (Eisenmann, 2006; Marmer *et al.*, 2011; Huang *et al.*, 2017; Zaheer *et al.*, 2019; Huang, Henfridsson and Liu, 2021, p. 3). Thereby, they grow their value creation by creating value for more customers. However, their ability to grow value creation does not imply an ability to capture value. For example, they may enter competitive markets that pressure prices, incur short-term costs of growth, or grow sales of unprofitable products (Bowman and Ambrosini, 2000; Bowman and Ambrosini, 2007). To improve their ability to capture value, they need to strengthen their bargaining power to customers, possibly focusing on a smaller, more profitable market, and control costs – either option reduces their growth in value creation (Hirakubo and Friedman, 2008). Focusing on growth in value creation without an ability to capture value, digital ventures lose resources during the growth process. They may try to compensate for this resource loss by raising capital to avoid bankruptcy (Marmer *et al.*, 2011; Monteiro, 2019). However, capturing value is critical for their long-term survival and sustainability (Thiel and Masters, 2014). For example, during economic crises and after capital market bubbles, new capital may not be forthcoming. At that point, the venture needs to sustain itself with the resources it generates (Jain, Jayaraman and Kini, 2008; Ojala, 2016). Therefore, this thesis aims to develop an understanding of the requirements and priorities, allowing digital ventures to develop an ability to capture value while growing their value creation. It investigates two specific research questions that contribute to achieving this aim:

1. How do value creation and capture develop for digital ventures?
2. What relationship(s) exist(s) between value creation and capture?

To answer these questions and achieve its aim, this thesis uses System Dynamics modelling to synthesise growth paths theory and dynamic states theory. As the third section of this chapter describes in detail, growth paths theory focuses on value capture in a cumulative process that leads to changes in firm size. Dynamic state theory focuses on value creation in discontinuous growth states that describe firm characteristics. Synthesising these views allows for a comprehensive description of the growth process. The System Dynamics model, developed based on these theories, can illustrate the complex relationships illustrated in the theories and in performance development over time. Answering the research questions using System Dynamics can thus illustrate performance trajectories and the impact of growth on digital entrepreneurs and managers. It can also describe the mechanisms driving diverse performance developments and settle the discussion about growth-profitability trade-offs and benefits. The two subsections below review the literature regarding those two questions and outline the need to investigate them further.

1.2.1. Development of value creation and capture

A company's ability to grow value creation and capture value changes as it grows. Conceptual papers have previously argued that as companies grow, they become better at capturing value and worse at increasing the value they create (Ireland, Hitt and Sirmon, 2003; Ketchen, Ireland and Snow, 2007; Hitt *et al.*, 2011). While this is true on average, companies develop diversely through different performance configurations (Steffens, Davidsson and Fitzsimmons, 2009; McKelvie and Wiklund, 2010). For example, Steffens, Davidsson and Fitzsimmons (2009) find that many, but not all, young firms can grow in sales. Moreover, their ability to turn higher sales into profitability differs diversely[1]. In a similar study, the same authors ordered Australian and Swedish companies into five performance configurations based on their sales growth and return on assets: poor, growth, profit, middle, and star (Davidsson, Steffens and Fitzsimmons, 2009). They then analysed how companies transition from the growth and profit configurations, where companies excel at one outcome, to the star and poor configurations, where they excel at both or no outcome. Figure 1-1 visualises their Swedish data set with the transition of companies from growth and profit to star and poor configurations over two years.

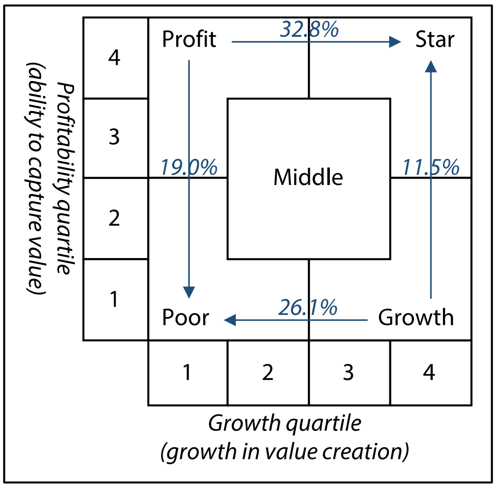


Figure 1-1: Profit-growth transitions (own graphic based on data collected by Davidsson, Steffens and Fitzsimmons (2009))

[1] Empirical studies commonly use revenue and profitability measures as proxies for the more abstract concepts of value creation and the share of value captured (Porter, 1985; Garnsey, Dee and Ford, 2006; Steffens, Davidsson and Fitzsimmons, 2009).

Figure 1-1 shows that companies are more likely to excel at both performance outcomes (transition to star configuration) if they previously achieved profitability rather than sales growth. However, the data shows that firms' performance configurations develop diversely. For example, 32.8 per cent of companies in the profit configuration developed to the star configuration. Another 19 per cent developed to the poor configuration. Here, the data set becomes incomplete as the authors only required developments from profit and growth to poor and star configurations in their analysis. The study does not account for 48.2 per cent of profit companies' transitions. These companies either stayed within the profit configuration or developed to the growth or middle configurations (Davidsson, Steffens and Fitzsimmons, 2009). Other authors investigating the transition between performance configurations have also observed this diversity in development paths (Brännback *et al.*, 2009; Jang, 2011).

While these studies provide empirical insights into the diverse development of performance configurations, the two performance outcomes "evolve in complex, multidimensional ways that are not well understood" (Steffens, Davidsson and Fitzsimmons, 2009, p. 126). Because previous authors studied a process that unfolds over time using variance-based methodologies, the studies cannot explain why specific mechanisms would dominate the development of some firms but not that of others (Pentland, 1999; Langley et al., 2013). Future research should explore the impact of explanatory variables on these different paths (Brännback *et al.*, 2009). Moreover, these mentioned studies have not investigated the development of value creation and capture in digital ventures. Therefore, this thesis investigates how value creation and capture develop over time for digital ventures.

1.2.2. Relationship(s) of value creation and capture

The above illustration of the development of value creation and capture also points to the relationship between the two performance outcomes. Davidsson, Steffens and Fitzsimmons (2009) illustrate that companies with high growth and low profitability rates are more likely to subsequently perform poorly regarding both outcomes than companies with high profitability but low growth (Figure 1-

1). Moreover, high growth companies with low profitability are also less likely than their counterpart to subsequently excel at both outcomes. Therefore, the authors argue that growth does not lead to profitability, but profitability may drive future growth.

However, empirical studies regarding the impact of profitability (i.e. ability to capture value) on growth (in sales and value creation) are inconclusive (Table 1-1). Some researchers argue profitability should drive growth as it illustrates that a company has developed a competitive advantage and its profit can fund its growth (Davidsson, Steffens and Fitzsimmons, 2009; Delmar, McKelvie and Wennberg, 2013; Nkwor and Ikpor, 2019). Other researchers find that profitability deteriorates growth because managers may forgo growth opportunities to maintain profitability or because profitable technology firms invest in product improvements rather than growth (Lee, 2018; Tong and Serrasqueiro, 2020). Yet others find no effect of profitability on growth, for example, because ventures can finance growth with external funding rather than profits (Markman and Gartner, 2002; Coad, Rao and Tamagni, 2011).

Table 1-1: Empirical literature on the growth-profitability relationship

Relationship	Literature
Profitability drives growth	Chandler and Jansen, 1992; Russo and Fouts, 1997; Roper, 1999; Mendelson, 2000; Brush, Philip and Hendrickx, 2000; Goddard, Molyneux and Wilson, 2004; Peng, 2004; Cowling, 2004; Fitzsimmons, Steffens and Douglas, 2005; Cho and Pucik, 2005; Brännback *et al.*, 2009; Steffens, Davidsson and Fitzsimmons, 2009; Davidsson, Steffens and Fitzsimmons, 2009; Jang, 2011; Jang and Park, 2011; Delmar, McKelvie and Wennberg, 2013; Adams *et al.*, 2014; Giotopoulos, 2014; Tien and Yang, 2014; Yazdanfar and Öhman, 2015; Kachlami and Yazdanfar, 2016; Maichel-Guggemoos and Wagner, 2019; Nkwor and Ikpor, 2019; Simbaña-Taipe *et al.*, 2019; Fernández-López *et al.*, 2019; Yadav, Pahi and Gangakhedkar, 2021; Eling, Jia and Schaper, 2021
Profitability deteriorates growth	Reid, 1995; Lee, 2014, 2018; Yoo and Kim, 2015; Tong and Serrasqueiro, 2020
Profitability does not affect growth	Markman and Gartner, 2002; Coad, 2007; Bottazzi *et al.*, 2010; Coad, Rao and Tamagni, 2011; Arrighetti and Lasagni, 2013; Federico and Capelleras, 2015; Ertan, Lewellen and Thomas, 2020; Léon, 2020
Growth drives profitability	Capon, Farley and Hoenig, 1990; Chandler and Jansen, 1992; Geroski, Machin and Walters, 1997; Russo and Fouts, 1997; Roper, 1999; Mendelson, 2000; Brush, Philip and Hendrickx, 2000; Peng, 2004; Cowling, 2004; Cho and Pucik, 2005; Coad, 2007; Asimakopoulos, Samitas and Papadogonas, 2009; Bottazzi *et al.*, 2011; Delmar, McKelvie and Wennberg, 2013; Lee, 2014; Yazdanfar and Öhman, 2015; Yoo and Kim, 2015; Federico and Capelleras, 2015; Senderovitz, Klyver and Steffens, 2016; Fuertes-Callén and Cuellar-Fernández, 2019; Maichel-Guggemoos and Wagner, 2019; Nkwor and Ikpor, 2019; Yadav, Pahi and Gangakhedkar, 2021
Growth deteriorates profitability	Reid, 1995; Fitzsimmons, Steffens and Douglas, 2005; Brännback *et al.*, 2009; Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009; Jang, 2011; Jang and Park, 2011; Nakano and Kim, 2011; Tong and Serrasqueiro, 2020
Growth does not affect profitability	Markman and Gartner, 2002; Bottazzi *et al.*, 2010; Lee, 2018; Ertan, Lewellen and Thomas, 2020

The research regarding the impact of growth on profitability is similarly inconclusive. Some researchers find a positive effect of growth on profitability because it, for example, creates learning effects and economies of scale (Katz and Shapiro, 1985; Delmar, McKelvie and Wennberg, 2013; Fuertes-Callén and Cuellar-Fernández, 2019). Others find the opposite, a negative effect of growth on profitability (Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009; Nakano and Kim, 2011). Theoretical arguments for such a relationship include, for example, the organisational turmoil created by growth and adjustment costs (Nicholls-Nixon, 2005; Greve, 2008; Penrose, 2009). Lastly, some authors find no effect of growth on profitability because the positive and negative effects of growth balance out one another (Markman and Gartner, 2002; Ertan, Lewellen and Thomas, 2020).

While most studies find a statistically significant positive relationship between growth and profitability, the strength of this relationship differs widely (Davidsson, Steffens and Fitzsimmons, 2009; Senderovitz, Klyver and Steffens, 2016). Some find only a very weak correlation between the two (e.g. Roper, 1999; Cho and Pucik, 2005). Others find a strong correlation between the two (e.g. Chandler and Jansen, 1992; Mendelson, 2000). However, despite the strong correlation, Chandler and Jansen (1992, p. 232) conclude that growth and profitability are “separate dimensions, and variables related to one are not necessarily related to the other, indicating the importance of considering both.” Moreover, differences regarding the relationship can be observed for different industry contexts (Brush, Philip and Hendrickx, 2000; Delmar, McKelvie and Wennberg, 2013), growth and profitability measures (Coad, Rao and Tamagni, 2011; Yoo and Kim, 2015; Fuertes-Callén and Cuellar-Fernández, 2019), and firm characteristics like company size (Yadav, Pahi and Gangakhedkar, 2021), information technology systems (Senderovitz, Klyver and Steffens, 2016), and strategy (Schlichter, Klyver and Haug, 2021).

The literature has also not investigated this relationship for digital ventures, although firm and industry characteristics affect it. Managers and entrepreneurs of digital ventures may argue that scaling-up, i.e. growing quickly, improves their ability to capture value (Zhang, Lichtenstein and Gander, 2015; Huang *et al.*, 2017; Zaheer *et al.*, 2019). While some of the above literature supports this view, it is also contradicted by empirical evidence in general samples of small and medium enterprises and other types of technology companies (Fitzsimmons, Steffens and Douglas, 2005; Brännback *et al.*, 2009; Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009). Therefore, this thesis focuses on a specific investigation of the relationship between growth in value creation and the ability to capture value for digital ventures.

1.3. Growth process theories as a conceptual basis

This thesis builds on the conceptual basis of growth process theories to answer the two research questions. Growth process theories conceptualise growth as “a process of development […] in which an interacting series of internal changes leads to increases in size" (Penrose, 2009, p. 1). These theories describe a company's internal changes and developments over time (Davidsson, Achtenhagen and Naldi, 2010). They can also be used to explain the development of value creation and capture (Pitelis, 2009).

1.3.1. Organisational life-cycle theory

Traditionally, organisational life-cycle (OLC) theory in the form of stage models has been the most influential growth process theory. Based on the analogy of living organisms, OLC theory assumes that companies are born, grow, and decline or renew themselves (Davidsson, Achtenhagen and Naldi, 2010). The theory postulates that all companies follow the same pattern of size changes (Levie and Lichtenstein, 2010). Stages of development have been added to the life-cycle to illustrate different firm characteristics as companies change in size. The theory defines each stage as a "unique configuration of variables related to organizational context and structure" (Hanks *et al.*, 1993, p. 7; Hoy, 2006). Thereby, different OLC models have identified different stages (Figure 1-2). For example, in their seminal article on OLC theory, Miller and Friesen (1984) identified different firm characteristics along the stages of birth, growth, maturity, decline, and revival. A model specifically developed for technology ventures has been proposed by Kazanjian and Drazin (1990). It includes the stages of conceptualisation, commercialisation, growth, and stability.

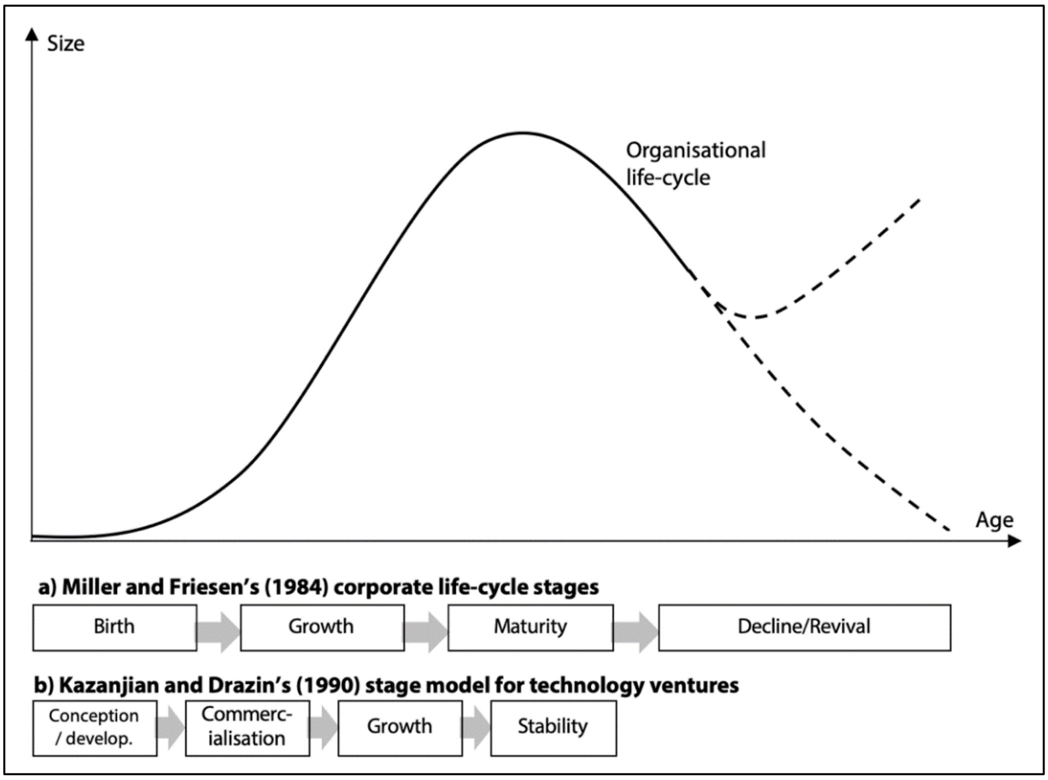


Figure 1-2: Organisational life-cycle and examples of stage models developed by Miller and Friesen (1984) and Kazanjian and Drazin (1990)

OLC theory provides some insight into the development of performance outcomes. For example, because companies develop new products and establish them on the market, the stages up to maturity/stability are more closely associated with growth in value creation (Miller and Friesen, 1984; Hanks *et al.*, 1993). During the maturity/stability and decline stage, companies are good at capturing value. While companies do not seek new opportunities during the maturity/stability stage, their established size should lead to economies of scale. During the revival stage, the company needs to enter new markets and launch new products. Thus, it increases the value it creates. Otherwise, adverse environmental factors such as increasing competition might cause the firm's decline (Miller and Friesen, 1984).

However, empirical studies have falsified OLC stage models due to their deterministic description of the growth process (Davidsson, Achtenhagen and Naldi, 2010). While changing firm characteristics could be identified as firms grow, research shows that one cannot order them in a single path that describes the development of all companies (Miller and Friesen, 1984; Stubbart and

Smalley, 1999; Stam, Garnsey and Heffernan, 2006). Moreover, stage models may be particularly unsuitable for digital ventures (Garnsey and Heffernan, 2005; Stam and Garnsey, 2006; Levie and Lichtenstein, 2010). Therefore, they "should no longer be used by scholars of entrepreneurship, for they act as a barrier to [the] advancement of research on the growth of entrepreneurial organizations" (Levie and Lichtenstein, 2010, p. 333).

Growth paths theory (Garnsey, 1998) and dynamic states theory (Levie and Lichtenstein, 2010) have been proposed as alternative theories explaining the growth process. They have been identified as the contemporary contributions that strive to advance growth process theories after OLC theory. Alternative approaches exist in the literature. However, these two theories have been highlighted as being "one of few recent efforts" and an "important vantage point". They also have been repeatedly mentioned in reviews of firm growth research (Davidsson, Achtenhagen and Naldi, 2010, p. 126; Leitch, Hill and Neergaard, 2010; McKelvie and Wiklund, 2010).

1.3.2. Growth paths theory

Growth paths theory aims to explain the diverse changes in size that companies experience. While OLC theory proposes a single growth pattern, growth paths theory identifies a range of development patterns. For example, Garnsey and Heffernan (2005) identified patterns in high tech companies, including continuous growth and growth setbacks, plateaus, or growth delays (Figure 1-3).

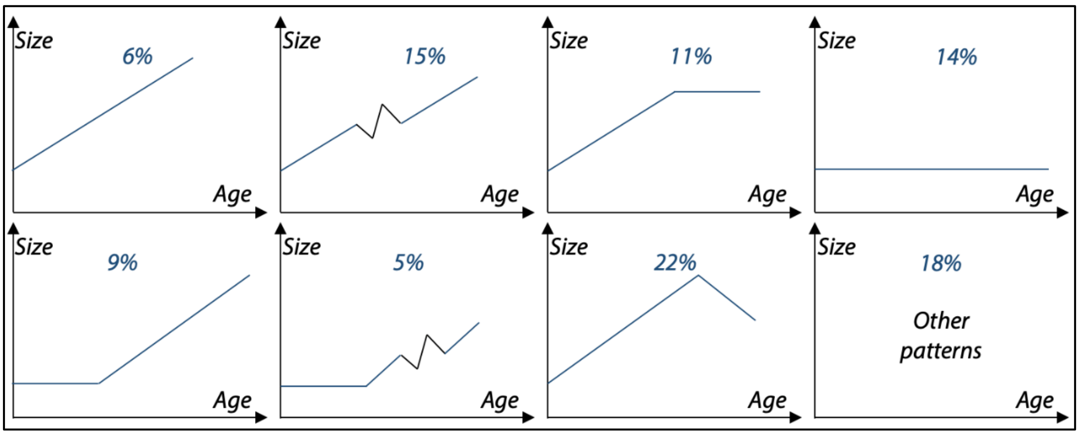


Figure 1-3: Growth paths identified by Garnsey and Heffernan (2005)

Based on Penrose' (2009) 'The Theory of Growth of the Firm', growth paths theory proposes the processes that may create these different growth patterns. It argues that digital ventures "match opportunities and resources in such a way as to initiate new activity that can create value" (Garnsey, 1998, p. 527). These opportunities emerge in the external environment, and a venture aims to pursue them utilising its resources and capabilities. If revenues from customers exceed the costs of inputs, the venture captures part of the value it creates for customers. These captured resources become part of the firm's financial slack. Thereby, they increase the venture's size, which the theory defines as the venture's total resources (Garnsey, Dee and Ford, 2006; Penrose, 2009). The financial slack may then be reinvested to pursue additional opportunities, creating an iterative process leading to different growth patterns (Stam, Garnsey and Heffernan, 2006). However, growth requires the venture's management to plan and execute the reinvestment activities. Therefore, the managerial slack slows down the iterative growth process in which resources and capabilities develop (Garnsey, 1998; Hugo and Garnsey, 2005; Penrose, 2009; Garnsey, Lubik and Heffernan, 2015; Miozzo and DiVito, 2016).

Growth paths theory advances growth process theories by highlighting the existence of different growth patterns. The theory also starts explaining these paths utilising Penrose's (2009) seminal work on company growth. However, the theory often remains abstract, reducing its implications for practitioners (Davidsson, Achtenhagen and Naldi, 2010). It requires further research to investigate and explain these different paths (Garnsey, Stam and Heffernan, 2006).

1.3.3. Dynamic states theory

Due to insufficient empirical evidence of stage models, researchers have proposed state models as an alternative theory for explaining the growth process. They relax the assumption that all firms grow through the same sequence of stages. Developing this conceptualisation further from a complexity theoretical perspective, Levie and Lichtenstein (2010) developed their theory of dynamic states. Their theory accepts that companies grow through different organisational configurations, i.e. states (Levie and Lichtenstein, 2010). However, dynamic states theory rejects stage models' assumptions of a specific number and predetermined sequence of stages. Instead, each state represents the entrepreneur's attempts to match the venture's business model efficiently and effectively to the external environment. Thereby, the activities, resources, and capabilities; the collaborations and supply chain; and the market position of the business model (Figure 1-4) are continuously adapted to create customer value. Entrepreneurs and managers will adapt their business models based on their dominant logic. This logic expresses their ambition, understanding of the environment, and their belief of what it takes to be successful in that environment (Levie and Lichtenstein, 2010).

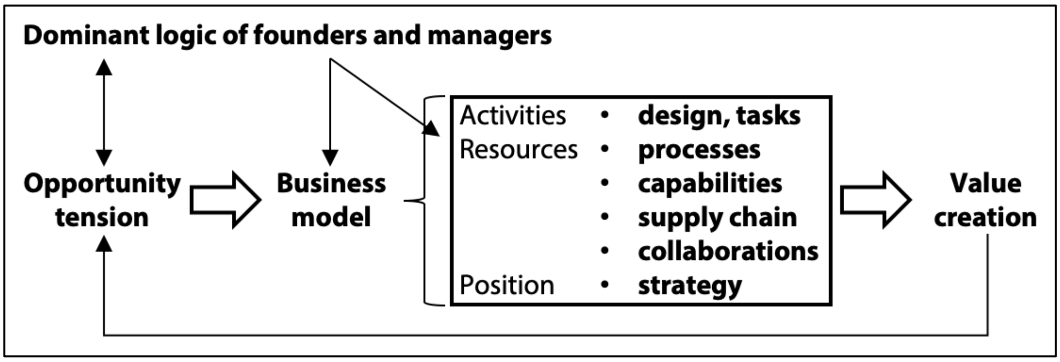


Figure 1-4: Elements of a dynamic state (Levie and Lichtenstein, 2010, p. 332)

Utilising Levie and Lichtenstein's (2010) original framework, Brown and Mawson (2013) identify a diverse range of trigger points that cause punctuated change and the transition between states. These may be endogenous (e.g. new product introduction, changing management), exogenous (e.g. macroeconomic changes), and co-determined (e.g. acquisitions, fundraising) trigger points. These trigger points cause punctuated changes between states (Harbermann and Schuilte, 2017).

Dynamic states theory presents a conceptualisation of states theory that avoids the criticism of stage models (Davidsson, Achtenhagen and Naldi, 2010). However, further research is required to explain the development experienced by companies in specific contexts and growth states (Levie and Lichtenstein, 2010).

1.3.4. The complementary nature of growth paths and dynamic states theory

Research suggests moving beyond OLC stage models to advance growth process theories (Davidsson, Achtenhagen and Naldi, 2010; Levie and Lichtenstein, 2010). Growth paths theory and dynamic states theory have been suggested as alternative conceptualisations of the growth process. They are complementary and compatible regarding their investigation of the growth process, underpinnings, description of the growth process, and performance outcomes (Table 1-2).

Table 1-2: Comparison of growth paths theory and dynamic states theory

	Growth paths theory	**Dynamic states theory**
Main underpinning	Process philosophy and research	Complexity science and complex systems
Description of growth process	Growth as a continuous and cumulative process • Resources and capabilities accumulate over time • Ventures pursue opportunities in the external environment and are under its influence Planned and implemented by managers and entrepreneurs	Periods of stability for the firm with punctuated change • Business model (including activities, resources, and capabilities; the collaborations and supply chain; and strategy) is adapted Managers and entrepreneurs adapt the business model based on their dominant logic
Element of the growth process	Starts with *change in size* and proposes mechanisms causing the change	Investigates the *change in firm characteristics* (i.e. business model) without considering size
Focus on performance outcome	Focuses on value capture as it increases the firm's size	Focuses on value creation in its conceptual framework

Both theories make use of similar philosophical underpinnings. Growth paths theory uses process research and philosophy, which investigates the temporal sequence of events (Van de Ven, 1992; Langley, 1999; Tsoukas and Chia, 2002). Dynamic states theory draws from complexity science and complex systems, and considers a large number of interrelated elements producing surprising, non-linear, and emergent effects (Anderson *et al.*, 1999; McKelvey, 2004). These two perspectives are related as tools from complexity science can be used to investigate processes (Anderson and Meyer, 2016). These philosophical underpinnings are adopted in this thesis and further discussed in the methodology section. Due to their similar philosophical underpinnings, the theories' different conceptualisations can be integrated to develop a comprehensive growth process theory.

Due to their different underpinnings, each growth process theory presents a different account of the growth process. In growth paths theory, the growth process is a continuous process. The theory conceptualises it as an accumulation of resources and capabilities over time. This accumulation depends on the management's ability to plan and reinvest for further growth (Garnsey, 1998). In dynamic states theory, the growing firm is presented as experiencing periods of stability with punctuated changes. During periods of stability, it maintains its business model. During transitions between states, the venture adapts its business model based on its managers' dominant logic (Levie and Lichtenstein, 2010). Both development patterns can be observed in companies and are thus necessary to explain the complete growth process (Hamilton, 2012).

The growth process is composed of "internal changes [which] lead to increases in size" (Penrose, 2009, p. 1). Therefore, growth process theories need to account for two aspects: internal changes and increases in size. OLC theory has previously done so. However, growth paths and dynamic states theory each provide a complex account of a company's growth process that focuses on, respectively, the increase in size or the internal changes. Growth paths theory explains the change in size on an abstract level (Davidsson, Achtenhagen and Naldi, 2010). Dynamic states theory focuses on the firm's elements, conceptualised as the business model, that change over time while not accounting for size in its framework (Levie and Lichtenstein, 2010). A comprehensive theory of growth requires the integration of dynamic state theory's changes in firm characteristics and growth paths theory's size changes.

Lastly, the two theories are complementary regarding their focus on performance outcomes. Both theories mention value creation and capture throughout their conceptualisation. Growth paths theory focuses on value capture. It explains that the captured value becomes part of the venture's resources. Because it defines size as the total of all resources, value capture contributes directly to the venture's change in size (Garnsey, 1998). However, the theory acknowledges that capturing value requires value creation (Stam and Garnsey, 2006). Dynamic states theory focuses on value creation. It includes value creation in its framework (Figure 1-4). However, the theory acknowledges that ventures do not just need to create value for customers. They also need to generate resources to sustain their growth state (Levie and Lichtenstein, 2010).

1.4. Thesis outline

This thesis thus utilises the theoretical foundations of growth paths theory and dynamic states theory to answer the above research questions about the development and relationship of value creation and capture for digital ventures. It strives to combine the two theories and overcome their individual limitations. It does so by building a System Dynamics model, which has been selected because it can answer the research questions while fitting to growth process theories' philosophical underpinnings and conceptualisations. This selection is further illustrated in Chapter 2 of this thesis. This methodology chapter also illustrates the foundations of the System Dynamics method and the process of developing, testing, and applying the model. This thesis thus follows the structure common in simulation research projects by placing the methodology chapter before the literature review.

Chapters 3 and 4 present the developed model and the theoretical basis used to develop it. The literature on growth paths theory, dynamic states theory and their foundational literature are combined to conceptualise the model (Chapter 3). Thereby, the thesis reveals the complex mechanisms affecting digital ventures' performance outcomes. Chapter 4 presents the formalisation and specification of the conceptual model for digital ventures as a mathematical model applying the principles of System Dynamics.

Chapters 5 and 6 simulate the model for case studies of real companies and hypothetical scenarios. Chapter 5 validates the model for four case studies of digital ventures. The chapter illustrates the model's ability to approximate the development of two software-as-a-service and two digital marketplaces over three to six years. Chapter 6 presents the simulation of the model for theory-driven but realistic hypothetical cases. Simulating different managerial decisions in different contexts allows identifying their impact on performance developments and relationships.

Chapter 7 discusses the implications of the model, the case studies, and the simulations for the two research questions and the aim of this thesis. Chapter 8 concludes this thesis with a discussion of its contribution, the strengths and limitations of its approach, and suggestions for future research.

Chapter 2: System Dynamics modelling methodology

This chapter presents the methodology and methods used to investigate the development and relationship of value creation and capture for digital ventures. Section one outlines the philosophical underpinnings of this research project. The subsequent section then proposes System Dynamics as a suitable and appropriate modelling method that suits these philosophical underpinnings, the research questions, and utilised theories. While the third section describes the development of the model, the fourth section focuses on its simulation for validation and insight generation.

2.1. Philosophical underpinnings and methodological requirements

Business and management scholars make use of different research philosophies that guide their research. These reflect a researcher's view on ontology and epistemology. Ontology refers to whether reality exists independently and objectively. Epistemology refers to what constitutes acceptable knowledge of that reality (Saunders, Lewis and Thornhill, 2012; Bryman and Bell, 2015). As illustrated in the introduction, this thesis builds on growth paths theory and dynamic states theory. These theories utilise process philosophy and complexity science, which adopt realism (ontology) and subjectivism (epistemology). This thesis also adopts these philosophical underpinnings and outlines the main propositions of process philosophy and complexity science below[2].

2.1.1. Process philosophy and research

Growth paths theory employs process philosophy and research (Garnsey, Stam and Heffernan, 2006). Central to process philosophy is the ontological view that

[2] The philosophical paradigm guides the entire research project. Therefore, it could also be argued, in reverse, that a researcher holds philosophical beliefs before selecting research questions and theories. The philosophy then implicitly triggers specific research questions and conceptualisations. These questions and conceptualisations would not be selected when holding another worldview (Bryman and Bell, 2015). For example, a researcher holding a process philosophical viewpoint may be more inclined to select a research question that investigates and explains change over time (Langley, 1999; Tsoukas and Chia, 2002; Chia, 2005).

reality consists of processes rather than entities. Processes have primacy over entities because entities only exist as manifestations that result from underlying processes at a point in time. Over time, processes change entities (Langley *et al.*, 2013; Helin *et al.*, 2014), such as digital ventures and their characteristics and performance. Process philosophy adopts an approach that is both realist (ontology) and subjectivist (epistemology). Thus, processes and manifestations of entities are assumed to exist objectively. However, our knowledge and understanding of these entities and processes are subjective and may differ (Chia, 1999). Process philosophy focuses on the emergence, change, and transformation that creates entities' manifestations and attributes (Chia, 1999; Tsoukas and Chia, 2002; Nayak and Chia, 2011). It prompts research that "is concerned with understanding how things evolve over time and why they evolve in this way" (Van De Ven and Huber, 1990, in Langley, 1999, p. 692). The introduction of this thesis is framed within such research questions. Process research then aims to identify the mechanisms and contingencies behind developments over time (Tsoukas and Hatch, 2001; Van De Ven and Poole, 2005).

In this context, the five main aspects that resonate with process philosophers are (Helin *et al.*, 2014):

- *Temporality*. While many organisational theories implicitly assume time, time is often not explicitly considered. Process research takes the passage of time into account to understand and explain evolving phenomena (Langley et al., 2013; Helin et al., 2014; Tsoukas, 2017).
- *Wholeness*. Rather than taking a reductionist approach that permits studying individual parts, process research postulates that change has a holistic and systemic effect. Therefore, process research needs to cover all parts of the whole, allowing connections between the parts, which increases complexity (Langley et al., 2013; Helin et al., 2014).
- *Openness*. Due to these connections, process research needs to emphasise the context of processes (Helin et al., 2014). This context gives rise to heterogeneity (Chia, 1999; Tsoukas and Chia, 2002; Hernes, 2008), which the introduction has illustrated for digital ventures' performance outcomes.
- *Force*. What drives and hinders processes are different forces, such as power, resistance, or pressure to achieve goals (Helin et al., 2014). These may be

endogenous or exogenous. Over time, they work as contingencies through the mechanisms underlying the processes (Pentland, 1999; Van De Ven and Poole, 2005).

- *Potentiality*. Potentiality reflects what might become a reality in the future through the processes (Helin et al., 2014). Thereby, what currently exists shapes what can be actualised as time passes. For example, current capabilities may determine a venture's growth potential. At the same time, current capabilities result from previous potentialities, such as learning and training (Hernes, 2008).

2.1.2. Complexity science and complex systems

Complexity science is concerned with systems composed of many elements and the behaviour created by the interrelationship between these elements (Dooley, 1997; McKelvey, 2004). Particularly dynamic states theory employs it explicitly to conceptualise new ventures' development process (Levie and Lichtenstein, 2010). Therefore, this thesis will need to employ research methods that can cope with complex systems to answer its research questions. Complexity science studies systems' behaviours and their diverse outcomes using formal models (McKelvey, 2004). Therefore, complexity science is well suited to investigate digital ventures' diversely developing performance outcomes (Davidsson, Steffens and Fitzsimmons, 2009; McKelvie and Wiklund, 2010).

The critical tool of complexity science is the notion of complex systems. Complex systems are composed of a large number of elements that interact dynamically through many connections. These relationships may be circular through positive and negative feedback (McKelvey, 2004; Lichtenstein and Plowman, 2009). Over time, this feedback causes non-linear behaviour where the system's outputs are disproportional to the system's inputs (McKelvey, 2004; Meyer, Gaba and Colwell, 2005). This non-linearity makes the systems particularly sensitive to their initial condition. Moreover, complex systems are open and affected by exogenous influences. Thus, different initial conditions and exogenous influences cause a system's behaviour over time (Dooley, 1997; McKelvey, 2004).

To investigate complex systems, researchers need to uncover a system's elements and the connections between elements, external influences, and time delays to investigate complex systems. Such research requires a combination of thick and thin descriptions (McKelvey, 2004):

- Thin descriptions use very few variables to explain outcomes using, for example, statistical analyses. Thin methods include traditional quantitative approaches, for example, simple and multi-variable regression analyses. These methods can generate generalisable results by utilising large samples. However, they often restrict the number of data points collected for each case in the sample (Saunders, Lewis and Thornhill, 2012; Bryman and Bell, 2015). These methods are thus unsuitable for investigating the development of complex systems because many relevant elements and their change over time are excluded (McKelvey, 2004). Some traditional quantitative methods allow for more complex relationships or longitudinal analyses. For example, structural equation modelling allows for more complex relationships between concepts and their measurements, and econometric methods allow for an investigation over time. However, both methods are still restricted to – compared to the real structure of complex systems – very few variables and rely on statistical inferences rather than causality and feedback that is required to understand them (Langley, 1999; McKelvey, 2004; Davis, Eisenhardt and Bingham, 2007; Miller and Tsang, 2010).
- Thick descriptions provide detailed accounts of developments, for example, in a single firm. They use traditional qualitative methods such as case studies or narrative inquiries facilitated using interviews with executives and thematic analysis. These methods have the advantage of uncovering the complex systems and processes that cause company development over time. However, due to the magnitude of data collected for each case, these methods often restrict themselves to few cases (Saunders, Lewis and Thornhill, 2012; Bryman and Bell, 2015). Therefore, they are unable to adequately test and generalise their findings (McKelvey, 2004; Schwaninger and Grösser, 2008; Miller and Tsang, 2010).

Instead of relying on traditional methods, McKelvey (2004) suggests combining thick and thin research approaches using simulation modelling. Computer models can provide comprehensive accounts of the mechanisms causing the development of individual cases. Such longitudinal case studies allow the uncovering of detailed, complex descriptions of their developments (Yin, 1981; Eisenhardt, 1989). They are thus able to provide thick descriptions. Researchers may also test simulation models using case study data. In addition, simulations allow the production of insight beyond cases and historical developments (McKelvey, 2004; Anderson and Meyer, 2016). Thereby, computer simulation can be generalised and provide thin descriptions. This thesis employs this combination of simulation modelling and case study testing to take advantage of their ability to generate rich and broad insight about the research questions that traditional quantitative or qualitative methods cannot generate.

2.2. Selection of System Dynamics modelling

Simulation modelling is the process of developing a formal model and experimenting with the model under varying conditions (Berends and Romme, 1999; Harrison *et al.*, 2007; Schwaninger and Grösser, 2008). A formal model is a computational representation of reality based on the underlying theory of the processes and system at investigation. Formal models express this theory mathematically (Davis, Eisenhardt and Bingham, 2007; Harrison *et al.*, 2007). Thereby, simulation modelling is situated at a *"sweet spot"* of theory development and testing (Davis, Eisenhardt and Bingham, 2007). Formal models expressing a theory can be tested and compared to actual, historical data. Moreover, researchers can use them for experimenting in a risk-free environment and without being constrained by the accurate measurement of constructs. Simulation modelling is thus a critical method to investigate complex systems (Langley, 1999; McKelvey, 2004; Anderson and Meyer, 2016).

2.2.1. Selection of System Dynamics as a modelling method

There are several modelling approaches, including agent-based modelling or fitness landscapes[3]. This project has selected System Dynamics. It is concerned with understanding complex, dynamic, time-dependent systems, and their behaviour. It is a rigorous modelling method that investigates the structure of systems with its circular causalities and feedback. These give rise to the system's non-linear behaviour (Coyle, 1996; Keating, 1999; Sterman, 2000; Morecroft, 2015). Davis, Eisenhardt and Bingham (2007) argue that simulation methods should be selected based on their fit to the underlying assumptions, research questions, and utilised theory. These aspects, which illustrate the suitability of SD for this research project, will be explored in the following paragraphs. They also compare System Dynamics to alternative simulation modelling techniques.

Underlying assumptions. System Dynamics is the simulation method that best fits this research project's philosophical underpinnings of process research and complexity science.

- Firstly, as its name suggests, System Dynamics focuses on the change of complex systems. It can provide thick descriptions of individual business cases by representing their continuous change across all relevant elements rather than focussing on, for example, individual agents or entities like agent-based modelling or discrete event simulations (Harrison *et al.*, 2007; Dangerfield, 2014). Like other simulation modelling approaches, the model's descriptions can be tested before generating data beyond observed cases (Sterman, 2000; Davis, Eisenhardt and Bingham, 2007).
- Secondly, System Dynamics addresses all five elements of process philosophy. It explicitly considers the temporality of processes by simulating delays and accumulation over time (van Oorschot *et al.*, 2013). Being designed to investigate systems, it can incorporate a high number of interacting elements, processes, and endogenous variables. It can also consider context explicitly through exogenous variables (Sterman, 2001; Azoulay, Repenning and Zuckerman, 2010; Rotaru, Churilov and Flitman, 2014). A system's development is entirely dependent on initial conditions,

[3] For a comprehensive review, see Davis, Eisenhardt and Bigham (2007) and Lichtenstein (2011).

exogenous influences, and the defined relationships. Therefore, System Dynamics models account for potentiality through path-dependence (Größler, Thun and Milling, 2008).

Research Questions. System Dynamics suits the research questions by unveiling mechanisms, generating practical recommendations for individual companies, and simulating variables even where exact measurement is impossible.

- Firstly, System Dynamics uncovers and illustrates complex causal relationships (Davis, Eisenhardt and Bingham, 2007). Thereby, System Dynamics models combine the strength of qualitative and quantitative methods. While qualitative methods such as Soft Systems Methodology can uncover complex relationships and visualise them, they are unable to test, generalise, and simulate identified relationships (Forrester, 1994; Wolstenholme, 1999; Coyle, 2000). Traditional quantitative methods such as structural equation modelling also include simple visualisations besides mathematical relationships. However, these are often restricted to few variables and linear, one-directional relationships. They are thus unsuitable for modelling the feedback loops that drive value creation and capture (Davis, Eisenhardt and Bingham, 2007; Harrison *et al.*, 2007). Other simulation modelling techniques, such as agent-based modelling, represent models without graphical representations (Coyle, 1996; Größler, Thun and Milling, 2008; Lichtenstein, 2011). System Dynamics models illustrate complex relationships graphically and mathematically. The graphical representation improves understanding of the model and allows a qualitative analysis of relationships and feedback loops compared to other simulation modelling approaches. System Dynamics models scale this connection of graphical and mathematical relationships to very complex models compared to the simple relationships expressed by traditional quantitative methods (Wolstenholme, 1999; Coyle, 2000, Sterman, 2000). Moreover, to improve comprehension of large models, System Dynamics includes additional tools to communicate overall insights of the model (Morecroft, 1982; Sterman, 2000). Lastly, the link between graphical and mathematical relationships ensures that even large, complex models can be audited and tested more thoroughly before simulating the mathematical relationships (Barlas, 1996).

- Secondly, System Dynamics can generate practical recommendations for individual ventures by building scenarios and determining optimal policies through simulation (Sterman, 2000; Täuscher, 2018). System Dynamics does so for a focal case company, rather than staying on the industry or population level like other simulation modelling methods such as fitness landscapes or genetic algorithms (Davis, Eisenhardt and Bingham, 2007). Moreover, unlike quantitative methods such as structural equation modelling, it can consider the exact conditions of a focal company rather than just making general statistical inferences based on few variables. Therefore, System Dynamics models like the one developed in this thesis can be used by practitioners to monitor, forecast, and manage their businesses, ensuring the practical relevance of academic work (Vhzquez, Liz and Aracil, 1996; Winch and Arthur, 2002).
- Lastly, simulation models are not constrained by the exact measurement and data availability of all variables (Langley, 1999; Harrison *et al.*, 2007). Value creation and the share of value captured, which are central to this thesis, cannot be measured accurately. Therefore, previous empirical studies used proxies to measure those performance outcomes. Such proxies commonly included revenue, revenue growth, and return on assets (Garnsey, Dee and Ford, 2006; Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009). System Dynamics allows calculating performance measures consistent with their theoretical conceptualisation and setting model inputs without numerical data for all variables. Instead, many System Dynamics models are parameterised based on analyst judgments and automatic model calibration when numerical values are unavailable (Sterman, 2000; Oliva, 2003, 2004; Walker and Wakeland, 2011). Therefore, System Dynamics is well suited to investigate the development of value creation and capture and can approximate those performance outcomes consistent with theory.

Utilised theories. Davis, Eisenhardt and Bingham (2007) argued that simulation modelling works best for simple theories that the selected modelling method can represent. Simple theories are underdeveloped. They may include only limited empirical or analytical grounding, few propositions, or an unformalised underlying logic (Davis, Eisenhardt and Bingham, 2007). Dynamic states and growth paths theory are such theories. Researchers have proposed them only in the last decade (dynamic states theory) or the last two decades (growth paths theory). They require further exploration because this short time frame limits the original and direct contributions to the theories (Davidsson, Achtenhagen and Naldi, 2010). Simple theories such as growth process theories can guide the modelling process, and formal modelling can advance them by identifying additional factors, relationships, and logical flaws (Malerba *et al.*, 1999; Davis, Eisenhardt and Bingham, 2007). Contemporary growth process theories represent growth as a complex, dynamic, and cumulative process (Garnsey, 1998; Levie and Lichtenstein, 2010). System Dynamics can capture this representation by incorporating constant change among variables governed by feedback, non-linearity, path-dependent behaviour, and stock accumulation (Sterman, 2001; Levie and Lichtenstein, 2010). Thereby, System Dynamics fits better to the theories utilised in this thesis than other modelling approaches that are less cumulative and more stochastic or adaptive like genetic algorithms or fitness landscapes. Moreover, System Dynamics models are uniquely suited to account for accumulation over time and time delays that the utilised theories suggest, which many quantitative methods such as regression analysis or structural equation modelling cannot consider adequately (Barlas and Carpenter, 1990; Vhzquez, Liz and Aracil, 1996; Davis, Eisenhardt and Bingham, 2007; Sterman, 2018).

2.2.2. System Dynamics modelling

Seminal authors have proposed slightly different processes to develop System Dynamics models (Table 2-1). The process starts with articulating the problem that requires a dynamic solution. Modellers then conceptualise the problem or system using causal loop diagrams. Through these diagrams, modellers formulate and express their dynamic hypothesis, their theory that accounts for the behaviour of the system. Modellers then formulate stock-and-flow diagrams and a formal simulation model based on these conceptualisations. Modellers and this thesis use the term formalisation to refer to developing stock-and-flow diagrams and mathematical relationships (Sterman, 2000; Harrison *et al.*, 2007; Ford, 2019).

Modellers then test the formal model by simulating it and comparing model approximations to actual data. After successful testing, the model can be simulated for hypothetical scenarios to evaluate the impact of varying organisational policies (Coyle, 1996; Sterman, 2000).

Table 2-1:Overview of proposed System Dynamics modelling approaches

<table>
<tr><th>Forrester, 1994</th><th>Coyle, 1996</th><th>Sterman, 2000; Morecroft, 2015</th><th>Martinez-Moyano and Richardson, 2013</th><th>This thesis</th></tr>
<tr><td></td><td>Problem recognition</td><td>Problem articulation</td><td>Problem identification and definition</td><td>Introduction
• Research need</td></tr>
<tr><td rowspan="2">System description</td><td>Causal loop diagrams</td><td rowspan="2">Formulation of dynamic hypothesis</td><td rowspan="2">System conceptualisation</td><td rowspan="3">Model development:
• Theory integration and model conceptualisation
• Theory contextualisation and model formalisation</td></tr>
<tr><td>Qualitative analysis</td></tr>
<tr><td>Conversion to equations</td><td>Simulation modelling</td><td>Formulation of simulation model</td><td>Model formulation</td></tr>
<tr><td>Model simulation</td><td>Model testing</td><td>Testing</td><td>Model testing and evaluation</td><td rowspan="4">Model simulation:
• Case simulation and validation
• Scenario simulation</td></tr>
<tr><td>Design alternative policies</td><td>Policy design</td><td rowspan="3">Policy design and evaluation</td><td rowspan="2">Model use, implementation, and dissemination</td></tr>
<tr><td>Educate and debate</td><td rowspan="2">Exploratory modelling and policy optimisation</td></tr>
<tr><td>Implement changes in policies</td><td>Design of learning strategy/infrastructure</td></tr>
</table>

This thesis breaks the modelling process activities into three steps. As stated in the introduction, this thesis aims to develop an understanding of the requirements and priorities allowing digital ventures to develop an ability to capture value while growing their value creation. The remainder of this chapter describes the steps to develop and simulate the model. First, this thesis develops a model in two steps that correspond to the chapters presenting the model. One chapter conceptualises the model based on the literature on growth process theories and identifies the main variables and feedback loops affecting performance outcomes. The other chapter specifies the model based on the literature on digital ventures and converts details of stock-and-flow formulations into mathematical equations. Second, the model simulated. This thesis simulates the model for case companies to test the model's ability to approximate companies' developments over time. It then simulates hypothetical scenarios to generate data and insight regarding the development and relationships of value creation and capture. Through these steps, this thesis reveals the mechanisms affecting these performance outcomes and explores the causes of their diverse development. They form a continuous circle of model development and simulation. Each step builds on the others, with continuous learning and iterations, to develop, simulate, and apply the model (Figure 2-1). Each iteration of this continuous development cycle adds to understanding the influences on performance outcomes and their development.

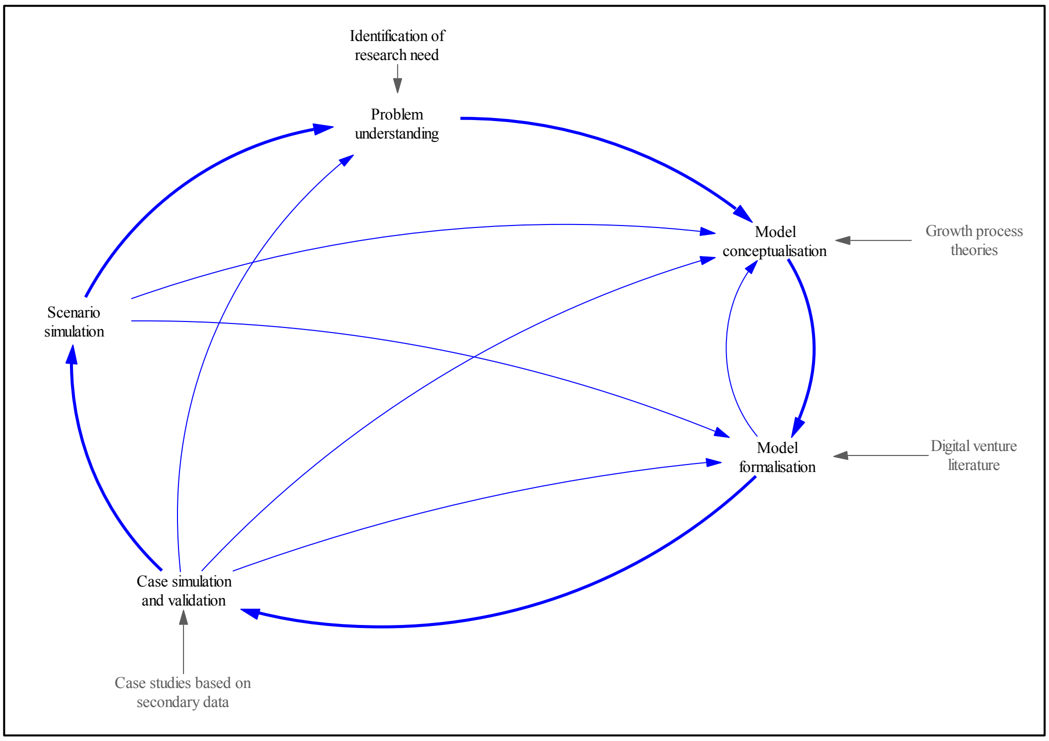


Figure 2-1: System Dynamics modelling process

The two sections below illustrate the steps to develop and simulate the model. Each of their subsections considers an individual step within development and simulation.

2.3. Model development

This thesis develops a System Dynamics model based on established theory to understand the development and relationships of value creation and capture. By building the model based on established theory, this thesis ensures that the model is generally applicable and theoretically informed (Coyle, 1996; Langley, 1999; Sterman, 2000). However, the model goes beyond visualising and formalising the established theories. This thesis aims to develop the theories further. It integrates growth paths theory and dynamics states theory, focuses the theories on performance outcomes, and contextualises them for digital ventures.

Due to the complexity of the phenomena under investigation, this thesis presents the developed System Dynamics model on different levels of aggregation. These levels of aggregation reflect different levels of detail provided about variables. On the one hand, too many details may hinder the communication of the central feedback loops that drive behaviour. On the other hand, too few details may create doubts and confusion about the relationships between variables (Sterman, 2000). Therefore, Coyle (1996) argues that modellers should overcome this tension by presenting causal loop diagrams with different levels of detail. In his illustration (Figure 2-2), Coyle suggests four such levels of detail. However, these levels are not strict guidelines. Instead, the levels of detail illustrated in a modelling project need to be selected based on the model's purpose and complexity. The size of the ellipses reflects the level of detail of each causal loop diagram. Modellers may use different variable names across these ellipses to aggregate variables but must maintain the overall insight and relationships between the elements across different detail levels. Causal loop diagrams should reflect the most fundamental insight and significant results as the most aggregated version. Modellers present the formal model's computer code with its fine details about variables as the most detailed version.

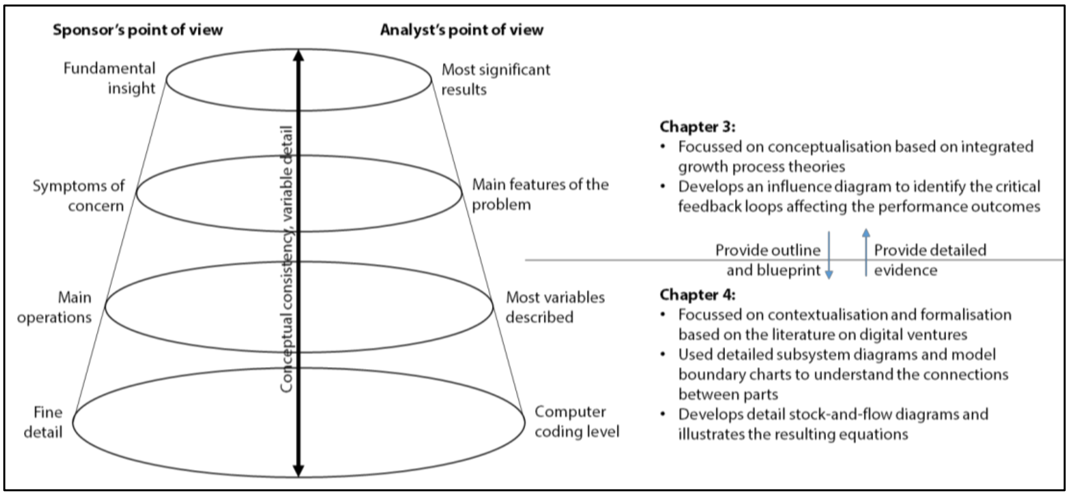


Figure 2-2: Cone of causal loop diagrams (adapted based on Coyle, 1996, p. 44)

This thesis also uses these different levels of detail and aggregation. Two separate chapters present the model at different levels of detail. Thereby, this thesis utilises the advantages of different System Dynamics conceptualisation tools. The subsubsections below review these tools. The structure also aims to indicate how the different types of literature – growth process theories and digital ventures – have been used in this thesis.

- Chapter 3 of this thesis focuses on model conceptualisation based on growth process theories. It builds and illustrates the model with its most important relationships driving the changes in performance outcomes. It identifies these relationships by integrating and synthesising growth process theories and their background literature. This description includes only the most essential details of digital ventures. The final causal loop diagram provides a strategic overview and summary of feedback loops affecting value creation and the share of value captured.
- Chapter 4 of this thesis focuses on contextualising and formalising the model for digital ventures. Additional details are added to the model utilising the literature on digital ventures. The chapter presents these details along subsystems using stock-and-flow diagrams which provide additional information required for model formalisation. It then illustrates the equations of the formal model. The end of each subsystem provides a model boundary chart to illustrate its links to other subsystems and exogenous model inputs.

The two model development chapters work as a tandem and are complementary. While the first chapter provides the blueprint and outline for the second chapter, the second chapter provides detailed evidence for the aggregated links in the first chapter. While the first chapter focuses on growth process theories, the second chapter focuses on the literature on digital ventures. While the first chapter utilises a more discursive and strategic language and tone, the second chapter focuses on the precise nature of variables and equations. Thereby, both are the result of the iterative modelling process outlined above. This process also includes the verification of conceptualisations and formalisations. The three subsections below illustrate the activities executed to develop these two versions of the model and their verification.

2.3.1. Model conceptualisation

A System Dynamics model has been conceptualised based on the literature on growth paths theory and dynamics states theory, and illustrated using causal loop diagrams.

2.3.1.1. Literature review

This thesis has synthesised the literature on the two theories to identify their relevant concepts and relationships. Existing literature reviews on growth process theories have identified the seminal articles on growth paths and dynamic states theory (see Davidsson, Achtenhagen and Naldi, 2010; Leitch, Hill and Neergaard, 2010; McKelvie and Wiklund, 2010). The author has identified additional contributions to the theories through forward and backward citation analyses. He has pursued this citation analysis iteratively and as a snowballing process until no additional contributions to the theories were identified. Thereby, this thesis has developed a comprehensive literature database on the two growth process theories (Tranfield, Denyer and Smart, 2003; Denyer and Tranfield, 2009; Wohlin, 2014; Bandara *et al.*, 2015). This literature was treated as data and analysed thematically to develop a conceptual framework and specify its elements and relationships (Bandara *et al.*, 2015). Previous reviews on digital ventures have also used this approach (see Zaheer, Breyer and Dumay, 2019). For example, this allowed the identifying of different resources, capabilities, and activities; different influences on performance outcomes; and different environmental factors.

In a second step, the author has identified secondary literature on which the growth process theories build. Growth is a holistic phenomenon that requires drawing from multiple business and management research fields (Leitch, Hill and Neergaard, 2010; McKelvie and Wiklund, 2010). Therefore, the author has evaluated the reference lists of seminal contributions to identify relevant background literature. This background literature provided additional insight into the development of the identified elements. For example, growth paths theory acknowledges that companies require complementary assets (Garnsey, 1998). Secondary literature further conceptualises complementary assets and their influence (e.g. Teece, 1986, 1998). This process adds details and relationships to the previously established framework (Bandara *et al.*, 2015).

2.3.1.2. Causal loop diagrams

The model conceptualisation chapter uses causal loop diagrams to communicate the variables and relationships identified in the synthesis of growth process theories and their foundational literature. Causal loop diagrams reveal the processes and mechanisms affecting variables of interest, including delays and exogenous variables (Figure 2-3). They capture System Dynamics' proposition that a system's behaviour emerges from feedback mechanisms among the variables (Sterman, 2000; Größler, Thun and Milling, 2008; Morecroft, 2015). Such causal loop diagrams illustrate the modeller's hypothesis about the causes of the system's and variables' dynamic changes. Therefore, they are commonly used to summarise a model and provide an overview of its most important insights. The causal loop diagrams used in the subsequent chapter of this thesis thus illustrate the most relevant feedback loops. As in other System Dynamics modelling processes, the causal loop diagrams developed in this thesis have also been analysed qualitatively. The combination of feedback loops is evaluated regarding their potential impact on performance outcomes over time (Forrester, 1994; Albin and Forrester, 1997; Wolstenholme, 1999; Sterman, 2000; Homer and Oliva, 2001).

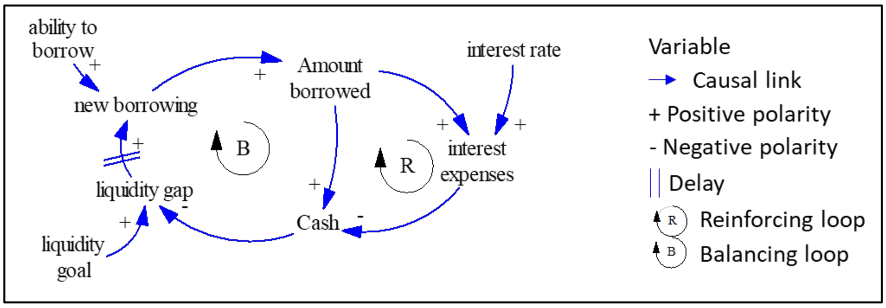


Figure 2-3: Example of a causal loop diagram

Each causal loop presented in a causal loop diagram consists of a set of variables that influence another circularly. The polarity illustrates the relationship between two variables (indicated with + or – on the arrow). The balance of polarities determines whether a loop is balancing or reinforcing (indicated with a B or R). While balancing loops represent dampening and goal-seeking feedback mechanisms that counteract change, reinforcing loops cause their own growth (Sterman, 2000; Morecroft, 2015). For example, such a goal-seeking mechanism may entice a company to borrow more money to raise its cash balance to its liquidity goal. New borrowing increases a company's interest expenses. It then reduces the cash balance, creating a reinforcing loop due to even more borrowing. The causal effects of feedback loops may be delayed (double crossed lines), which explicitly account for temporality (Sterman, 2000; Morecroft, 2015). Moreover, a feedback loop may be affected by exogenous variables or parameters. These are not part of the loop itself but affect it (Coyle, 1996), such as the interest rate in the illustration above. These exogenous influences capture the openness of processes considered in process research (Azoulay, Repenning and Zuckerman, 2010).

2.3.2. Model formalisation

This thesis then builds on these causal loop diagrams to specify and formalise the model for the context of digital ventures. Because the literature on growth process theories applies to a diverse range of companies, the processes they describe remain abstract (Davidsson, Achtenhagen and Naldi, 2010). Adding literature on digital ventures allows specifying, for example, how resources or activities materialise for digital ventures. In addition, some elements included in growth process theories may also not apply to digital ventures (e.g. inventories), while they require additional elements (e.g. different business model designs). The author has identified such adaptations by reviewing contradictory evidence between the growth process literature and digital venture literature. The identified variables and relationships in growth process theories have thus been challenged critically using the literature on digital ventures. This thesis uses stock-and-flow diagrams, subsystem diagrams, and model boundary charts to communicate this detailed model version. Equations are then formulated based on the stock-and-flow diagrams.

2.3.2.1. Stocks-and-flow diagrams, subsystems, and model boundaries

This thesis utilises stock-and-flow diagrams to illustrate the detailed version of the model. They capture additional information required for formal models, such as the nature of variables. Stocks, also called levels and represented by boxes, preserve their value. They accumulate through their inflows and outflows, illustrated by arrows and valves. Some System Dynamics modellers also refer to flows as rates to highlight that they represent instantaneous rates of changes, i.e. at any point in time, a rate variable illustrates the amount the stock changes per period. Consistent with process philosophy, stocks and flows thus capture that stocks as entities are not existent by themselves. Instead, they are a temporal manifestation of the continuous in- and outflow processes changing them. When modelling businesses using System Dynamics, balance sheet items should be modelled as stocks. Items from the income or cash flow statement should be flows or auxiliary variables. Therefore, most performance variables used by managers reflect outcomes achieved over a period of time. Examples include revenue or profit, which are usually modelled as flows or auxiliary variables (Coyle, 1996; Albin and Forrester, 1997; Sterman, 2000; Warren, 2002; Morecroft, 2015). The two balance sheet items – *cash* and *amount borrowed* – in the example above (Figure 2-3) are converted into stocks (Figure 2-4). They are not altered directly but only through flows such as revenues and expenses increasing or decreasing cash (Sterman, 2001).

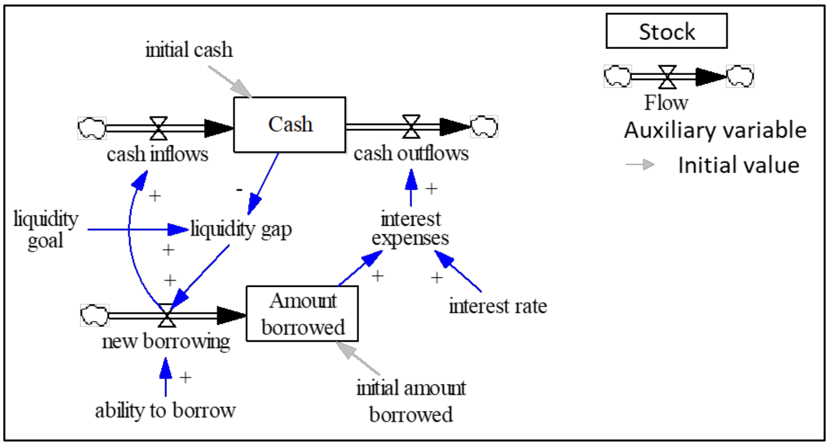


Figure 2-4: Example of stocks-and-flow-structure

Stocks require initialisation to simulate models. The processes and causalities represented by causal loops will then change the initial value of stocks via the inflows and outflows over time (Größler, Thun and Milling, 2008). This process is path-dependent, meaning the initial value of a stock directs the behaviour of the system. In theory, modellers could reduce the complexity of all System Dynamics models to stocks and flows. However, they usually include auxiliary variables in the model to detail causal chains (Morecroft, 1982; Coyle, 1996; Albin and Forrester, 1997).

The detailed version of the model cannot be captured in a single stock-and-flow diagram because it contains too many variables and relationships. Each stocks-and-flow diagram presented in Chapter 4 of this thesis thus captures a small part of the model. The chapter uses two additional tools to communicate how these individual parts of the model interact with another:

- *Subsystem diagrams* illustrate the major parts or sectors of the model, which group variables together. Such groups may be established based on, for example, organisational units or conceptual similarities between variables (Morecroft, 1982; Sterman, 2000). Such subsystem diagrams communicate the model's boundaries. They also help structure the model's presentation by signposting which model elements are described in which part of the documentation (Morecroft, 1982; Sterman, 2000).
- *Model boundary charts* are a critical tool to analyse System Dynamics models. These tables explicate and assess the model's endogenous (calculated in the model), exogenous (external influence affecting calculations), and

excluded variables (not considered in a model). By highlighting the model's scope, model boundary charts allow challenging the assumptions underlying the model's overall structure. Together with initial conditions, exogenous influences determine the balance of feedback loops within the model. Explicating these variables allows challenging whether exogenous influences should be part of the model's feedback structure (Albin and Forrester, 1997; Sterman, 2000). Chapter 4 of this thesis presents a model boundary chart at the end of each subsystem. These illustrate the connections to other subsystems and the exogenous parameters influencing this part of the model.

2.3.2.2. Variable formulation

The relationships between variables illustrated in stock-and-flow diagrams have been converted to mathematical equations to develop a formal model. This process went back and forth between the detailed stock-and-flow diagrams and equations. The author used Coyle's (1996) common module method to facilitate this iterative process. It models a set of connected variables utilising reappearing structures in System Dynamics models (e.g. s-curves, goal-seeking behaviour). Sterman's (2000) extensive System Dynamics modelling guide and previous papers have been used to identify appropriate structures. They have been used to rework stock-and-flow diagrams and formulate their equations. Moreover, the author assigned each variable a unit based on the concept it represents in reality.

The nature of variables identified in stock-and-flow diagrams determines which equations are allowed in System Dynamics models. This thesis has utilised different approaches to set equations for stocks, hard variables, and soft variables.

- System Dynamics formulates the accumulation process of stocks through its associated flows using integration. Therefore, the value of a stock is calculated by integrating its net flow and adding it to its initial value. The net flow represents the rate of change per unit of time, which the software calculates by subtracting the outflows from the inflows (Coyle, 1996; Sterman, 2000; Warren, 2002; Harrison *et al.*, 2007; Dangerfield, 2014; Morecroft, 2015).
- Flow and auxiliary variables are not constrained to integration. Their equations are derived by connecting their affecting variables based on the

underlying theory and conceptualisation. In the case of variables representing hard concepts, such as amounts of money or employees, equations can be derived by reviewing the concept each variable represents (Coyle, 1996; Sterman, 2000; Warren, 2002; Dangerfield, 2014; Morecroft, 2015). For example, the *liquidity gap* in Figure 2-4 might represent the absolute difference between the company's *liquidity goal* and its current *cash position*. Therefore, one may calculate it by subtracting the cash at hand from the liquidity goal. Modellers can calculate the *interest expenses* by multiplying the *amount borrowed* with the *interest rate*.

- System Dynamics models can also account for soft or qualitative variables. These variables may include, for example, product quality or a company's capabilities. While analysts cannot assess these variables accurately and measure them numerically, some qualitative information might exist. System Dynamics modes should include soft variables because their exclusion would assign them the value and impact of zero – the only value and impact known to be false (Sterman, 1991, 2000, 2001, 2002; Forrester, 1994; Homer and Oliva, 2001; Größler, 2007; Kunc, 2017, 2018). Two approaches have been used in this thesis to formulate soft variables and connect them to the hard variables: Firstly, some authors have suggested using *indexed variables*. Thereby, the modeller assigns a soft variable the value of one at the beginning of the simulation. The modeller needs to normalise the impact of influencing hard variables to achieve this indexing, usually by dividing the current by the influence's initial value. Different influences can then be added up, multiplied, or weighted using parameters representing the influencing variables' effect sizes. Modellers may then use a standard rate to connect the soft variable to the hard variables of the system. This standard rate represents the effect of the indexed variable on a hard variable. The standard rate may be based on expert judgements or calibrated automatically by the modelling software (Hennessy, 1997; Sterman, 2000; Walker and Wakeland, 2011). Secondly, modellers suggest using soft *variables as filters* with ranges between zero and one. The variable has its most significant impact at a value of one and no impact at zero (Coyle, 2000; Warren, 2002; Dangerfield, 2014). Warren (2002) uses such filter variables to model capabilities compared to best practice or a theoretical maximum. A capability may, for example, reflect the average employees' ability to acquire new customers. Together with the best practice or maximum, this capability affects the outcome of the capability on a hard variable (Coyle, 1996; Sterman, 2000; Dangerfield, 2014).

Variables in System Dynamics models are assigned units, which modellers need to set according to the concepts they represent. Variables' units fulfil two critical purposes. Firstly, units aid modelling equations because an outcome variable's unit needs to correspond to the unit that emerges from its equations. Therefore, the units of the variables provide insight into how modellers need to combine variables in equations. When verifying the model (see Subsection 2.3.3), a dimensional consistency test ensures that all equations fulfil this requirement and the model's equations can easily be checked. Secondly, these units aid in simulating and validating the model because the units hint at the data points corresponding to the variables. This thesis has adhered to four rules when assigning units (Coyle, 1996; Sterman, 2000; Warren, 2002; Morecroft, 2015):

- The units of a flow have the corresponding stock's units per unit of time. Modelling business problems, balance sheet items are assigned units of dollars (in this thesis, irrespective of the actual currency). Their flows such as cash flow, depreciation, revenue are thus assigned units of dollars per period. Human resources are commonly measured in the number of employees, and their flows like hiring have the units of employees per period. Customers are measured in the number of customers. They are acquired and lost through variables with the units of customers per year (Coyle, 1996; Sterman, 2000; Warren, 2002; Dangerfield, 2014; Morecroft, 2015).
- Fractions are always dimensionless, shorted DMNL in models. Such fractions express, for example, the fraction of sales spend on research and development.
- Fractional flow rates have units of one per period. For example, these reflect the interest rate, which expresses how many units of money in interest expenses a business incurs for each unit of money per period. This term can be shortened to one per unit of time.
- The unit of time has been set to one year to align with data availability in annual reports.

2.3.3. Model verification

All models represent a simplified version of reality developed from a specific perspective. Model testing is thus concerned with building confidence in the model and ensuring the model is appropriate for its intended purpose (Coyle, 1996; Sterman, 2000; Morecroft, 2015). In the iterative model development process (Figure 2-1), modellers may then reconceptualise the model or alter its equation (Forrester and Senge, 1979; Sterman, 2000). Model testing can be split into verification and validation (Kleijnen, 1995; Sargent, 2013). The next section further discusses validation as part of the model's simulation (Subsection 2.4.1). Verification ensures that the model implements the underlying theories accurately by ensuring the model's equations are free of inconsistencies and errors (Sargent, 2013). Forrester and Senge (1979), Barlas (1996), Sterman (2000), and Morecroft (2015) define the verification tests for System Dynamics models:

- A first test to be executed is a *structure verification test*. It compares the modelled feedback loops with information about the system, such as academic literature (Barlas, 1996). This test also ensures that the model is free of inconsistencies, including inappropriate assumptions, such as negative stocks (Barlas, 1996; Sterman, 2000). For example, the number of employees of a venture cannot logically fall below zero. Minimum and maximum values have been set for variables to apply this test to the developed model. The Vensim software warns the modeller when a simulation breaches these values.
- A *parameter verification test* checks that exogenous parameters match the knowledge of the system conceptually and numerically. Conceptually, all parameters must represent identifiable elements of the real system. Numerically, one must then be able to approximate all parameters with sufficient confidence (Forrester and Senge, 1979; Barlas, 1996; Sterman, 2000; Morecroft, 2015). This thesis thus defines all exogenous variables to illustrate the elements they represent in reality. It proposes measures to estimate inputs utilising the information presented in annual reports (see Appendix C).

- A *boundary adequacy test* ensures that all relevant feedback loops are included in the model to satisfy the model's purpose (Forrester and Senge, 1979; Morecroft, 2015). The two tests previously introduced provide information regarding this inclusion. For example, negative stocks often indicate that a modeller has not considered a balancing feedback structure that reduces outflows to zero. Additionally, another look at the model's parameters is required. Modellers should include the feedback structure that causes inputs to change if these inputs are not constant over the period of interest (Coyle, 1996; Sterman, 2000). This test has been executed when validating the model with case data (Subsection 2.4.1) by assessing if input parameters are reasonably constant within a growth state.
- A *dimensional consistency test* analyses the model's equations. It ensures that the equations used to connect variables compute an output with the same units as assigned during the formalisation step (Forrester and Senge, 1979; Barlas, 1996). The simulation software can operate this test automatically (Coyle, 1996; Oliva, Sterman and Giese, 2003).
- Equations also need to compute reasonable outputs for all possible inputs. An *extreme conditions test* evaluates the equation's output under extreme input values (Forrester and Senge, 1979; Barlas, 1996; Sterman, 2000; Morecroft, 2015). These extreme conditions may be the parameter's minimum or maximum values assigned to them during formalisation or extraordinarily low and high numbers.

The thesis has used these five interrelated tests to verify the model thoroughly. They ensure that the formal model implements the interpretation and conceptualisation of growth process theories and the literature on digital ventures. If the model fails any of these tests, further model development takes place to refine the model. Thereby, the iterative process illustrated above (Figure 2-1) continued until a verified model was developed.

2.4. Model simulation

Causal loop diagrams and the other conceptualisation tools already provide insightful descriptions of the system and processes at work. Simulating the corresponding formal model provides the means to test the model, confirm its structure, and generate further insight. Thereby, further confidence in the model's ability to approximate actual developments is established. Moreover, System Dynamics models often include feedback loops that work against another. In such cases, analysts cannot predict the system's behaviour because it depends on the balance of feedback loops. Simulating the model allows determining the balance of feedback loops and generating data through the model (Wolstenholme, 1999; Sterman, 2000; Homer and Oliva, 2001; Kunc, 2017). This thesis simulates the model for case studies of digital ventures to validate the model (Chapter 5). It then simulates hypothetical scenarios to generate further insight about value creation and capture (Chapter 6). Both types of simulation are discussed in the two subsections below. Simulations are then analysed to answer the research questions outlined in the introduction and achieve the aim of this thesis.

2.4.1. Case simulation and model validation

The model is first simulated for case companies to validate it. This validation tests the model's ability to approximate the development of companies over time. Similar to verification, validation allows establishing the level of confidence in the model's approximations (Kleijnen, 1995; Sargent, 2013). The selection of case companies, the model's set up for each company, and the comparisons of model and historical data is illustrated below.

2.4.1.1. Case study identification and selection

Case companies have been identified through an extensive and rigorous search and filtering process of two different sources. The first source is the Financial Times's (FT) 1000 fastest-growing companies lists. The lists have been published since 2017 and include companies that have submitted entries for inclusion in the ranking and companies identified through the FT's additional research. The lists cover the 1000 European-based companies with the highest organically achieved compound annual revenue growth rates over the three years before the submission period[4]. The second source used to identify companies was the NASDAQ's initial public offerings (IPO) calendar. It includes companies that went public on major US stock exchanges and NASDAQ-owned international stock exchanges. These have been included because the NASDAQ is the leading technology stock exchange (Geron, 2013).

The 2017, 2018, and 2019 editions of the FT's list (total of 3000 companies) and all companies on the IPO calendar that went public between January 2010 and December 2019 (total of 1868 companies) have been considered. These companies have been filtered through numerous steps. The first two steps have only been applied to the FT lists.

- From the FT lists, only companies based in the United Kingdom have been included to ensure that their annual reports can be accessed through the university's database subscriptions and to avoid language barriers.
- Because some companies may be included in multiple editions of the FT list, duplicates among the lists have been eliminated.
- Company descriptions and websites have then been scanned to identify digital ventures. Companies providing physical products or services have been eliminated from the sample as they do not fit the characteristics required for this investigation. Many companies eliminated through this step are natural resource, energy, manufacturing, electronics, or biotechnology companies.
- Financial technology companies have been excluded because their growth behaviour deviates significantly from producing companies. They are generally excluded from growth process theories (Penrose, 2009).
- Digital ventures with all required data points (see Appendix C) for model inputs and outputs over at least four years have been selected. Many companies included on the FT lists are exempt from publishing full annual reports due to their small size and private ownership. Thus, a significant number of companies had to be excluded through this filter.

[4] For example, companies in the 2019 list are ranked based on their revenue growth rate between 2014 and 2017. To be considered in the ranking, companies must have achieved at least 100,000 EUR in revenues (or currency value equivalent) in the first year and 1.5 million EUR in revenues in the final year of the three-year period. Companies must also be independent, i.e. not branches or subsidiaries of other companies.

- Because this project aims to understand how digital ventures can develop an ability to capture value while growing their value creation, only companies with initially negative profitability have been selected. Companies growing to develop an ability to capture value often do so with their first product and organically. Therefore, companies that grow through acquisitions, diversification, or new product introduction have been excluded.

Through this filtering, four companies have been identified. These allow testing the model in various settings and across different industries, business models, locations, sizes, growth rates, and profitability measures. This diversity is required to ensure the model can approximate companies in various situations and identify the boundaries for which the model is suitable (Groesser and Schwaninger, 2012). For example, while two companies operate as software-as-a-service (SaaS) providers, two companies operate online marketplaces. This diversity allows testing the model for a variety of digital business models. While the FT companies are smaller with higher growth rates, the NASDAQ list includes more mature companies with lower growth rates. Therefore, the model can be tested against different development paths and sizes. As a requirement of this project's ethical approval, companies remain anonymous. The terms Alpha, Beta, Gamma, and Delta will be used throughout this thesis to refer to the four companies.

2.4.1.2. Model parameterisation and calibration

Initial values and exogenous parameters must be set to simulate the model for each case company (Sterman, 2000, 2001). System Dynamic modellers should use all available data, not just numerical time-series data (Forrester, 1987). Similarly, case studies can use qualitative and quantitative information (Yin, 1981; Eisenhardt, 1989). Therefore, annual reports have been used by System Dynamics modellers (Oliva, Sterman and Giese, 2003; Sterman *et al.*, 2007) and growth process researchers (Kor and Mahoney, 2000; Greve, 2008; Gabrielsson and Gabrielsson, 2013; Miozzo and DiVito, 2016). Annual reports include reliable quantitative financial and operational information as well as important qualitative management commentary (Cowton, 1998; Rowbottom and Lymer, 2010). For System Dynamics modellers, this balance allows setting model inputs based on the quantitative data without subjective assessments while also providing them with contextual information. For growth process researchers, annual reports have the advantage of being a reliable source of information because they are legally bound to include accurate information. They are also permanent documents that avoid hindsight bias (Nikula *et al.*, 2010; Saunders, Lewis and Thornhill, 2012; Bryman and Bell, 2015).

Annual reports have first been analysed qualitatively to identify growth states. As suggested by dynamic states theory, the management may alter the business model periodically. Thus, the firm exhibits periods of stability punctuated by abrupt change (Levie and Lichtenstein, 2010; Brown and Mawson, 2013; Harbermann and Schuilte, 2017). These periods of stability have been identified by analysing the qualitative information in annual reports using a time-ordered matrix (see Miles, Huberman and Saldana, 2014) and temporal bracketing (see Langley, 1999).

- A time-order matrix organises qualitative data along two axes: time and categories (Miles, Huberman and Saldana, 2014). The qualitative information in annual reports has been reviewed for important information about input variables and output variables. Relevant information about variables has been coded regarding the year they refer to (time) and the variables (categories). A coding scheme with years and variables has been set up in NVivo, and the matrix has been created using the software's matrix search function. This computer-aided qualitative analysis has the advantage of streamlining the process of qualitative data analysis. It allows researchers to maintain an overview of collected and coded information over hundreds of pages of annual reports and multiple reports per company. Computer-aided analysis has also improved data analysis using automatically generated matrixes (Yearworth, 2010; Bandara *et al.*, 2015; Gaur and Kumar, 2018).
- Temporal brackets in case companies' developments have been identified using these time-ordered matrixes. In Langley's (1999) temporal bracketing strategy, phases of development are identified. Elements of interest remain constant during each phase, while these elements change when transitioning between phases. As Langley (1999) argues, these phases are not a predictable, theoretical sequence but instead describe and order case data. Therefore,

temporal bracketing fits well the assumptions of growth states in dynamic states theory. These brackets have been identified by reviewing the statements made each year about variables. Years are summarised and divided into growth states based on constant input variables.

Parameter values must be set for all input variables based on the company's growth states. Dynamic states theory's conceptualisation of growth states indicates that some variables are constant during a growth state (Levie and Lichtenstein, 2010; Brown and Mawson, 2013; Harbermann and Schuilte, 2017). Therefore, most inputs variables were held constant during a growth state.[5] Based on the qualitative analysis of annual reports, the analyst has assessed if the change in a growth state justifies a change in an input variable. If a change could not be justified, the variable has been held constant over multiple growth states. For example, a company no longer planning to scale up its customer base justifies lowering a target growth rate. However, it does not justify changing the market prices of resource inputs. System Dynamic modellers use a combination of techniques to estimate input variables. These fall into three categories (Sterman, 2000, 2001; Morecroft, 2015; Kunc, 2018):

- Hard, quantitative variables can usually be set based on case data with no or only minimal transformation. Such hard variable might, for example, refer to the initial number of employees or revenue in different years. Such hard variables are set based on annual reports' financial and operational data (Morecroft, 2015). Numerical data has been indexed to obscure the identity of case companies as required by the ethical approval for this project. Due to this indexing, many initial values have been set as one (further details on indexing in Chapter 4 with the relevant variables). Where hard input variables are constants over multiple years, the average over these years in which the variable was held constant has been used.
- Soft, qualitative variables such as product quality or switches implemented in the model to reflect different policies can be set based on the judgement of the analyst. Guidelines to set variables based on a qualitative analysis of annual

[5] Only a few selected input variables have been allowed to change during growth states and from year to year. These variables relate to accounting figures such as taxation, which are subject to complex rules (i.e. tax law) that are not the subject of this thesis.

reports have been developed for such switches and soft variables. These guidelines are based on previous research and the model's equations. For example, initial capabilities, which are qualitative variables between zero and one, are assessed using the capability maturity model with five levels (Garud, Kumaraswamy and Sambamurthy, 2006; Belt *et al.*, 2009; van Oorschot *et al.*, 2013).

- Some model parameters may be set using automatic model calibration. Such automatic model calibration is used in System Dynamics when no data is available to estimate an input variable. Examples may include standard rates that are used in some common System Dynamics structures such as s-curves. System Dynamics software includes features to estimate such unknown variables. The software identifies input values that achieve the closest fit between other observable variables and their historical data (Kleijnen, 1995; Berends and Romme, 1999; Sterman, 2000; Walker and Wakeland, 2011; Rahmandad and Sterman, 2012). This calibration is an important part of model validation. It tests if the modelled structure can replicate the behaviour observed in variables of interest (Lyneis and Pugh, 1996; Oliva, 2003, 2004; Homer, 2012). Oliva (2003) further highlights that modellers should evaluate calibrated inputs for their feasibility and consistency. Regarding feasibility, modellers should evaluate if set values are theoretically possible. Regarding consistency, modellers should evaluate if values align with other information available. For example, negative values for employee turnover would be a breach of feasibility. Employee turnover of over a hundred per cent may be inconsistent. Modellers should question it because industry averages are usually much lower (see Baron, Hannan and Burton, 2001; Gjerløv-Juel and Guenther, 2019).

Appendix C lists all hard, soft, and automatically calibrated variables. For variables set based on quantitative or qualitative information, the appendix also includes calculations, transformation/indexing, and other guidelines to set each variable. For automatically calibrated variables, the appendix includes details on the feasibility and consistency checks. The author has collected all input values for a company in a standardised Excel spreadsheet. The Vensim software reads the input values from the spreadsheet to run the model.

2.4.1.3. *Model validation*

Validation tests the model's ability to approximate the system's behaviour (Sargent, 2013). Modellers usually execute it through a behavioural reproduction test. It tests the model's ability to replicate the system's symptoms, fluctuations, and modes of behaviour (Forrester and Senge, 1979; Barlas, 1996; Sterman, 2000; Morecroft, 2015). This thesis validates the developed model through a subsystem strategy. It compares the development of hard, quantitative variables to case companies' historical data graphically (Chapter 5).

Researchers need to decide which variables will be compared to historical case data to validate the model. By simulating the model for each company with the company's unique model inputs, the model computes the development of each endogenous variable for each company. This thesis compares all subsystems' hard, quantitative outputs to historical data to holistically validate the model. Validating each subsystem ensures that individual parts of the model are functioning as intended. It allows the spotting of additional errors that are cancelled out when reviewing only value creation and capture as the focal performance outcomes of this thesis. Moreover, designing subsystems with hard, quantitative outputs ensures that these outputs are objectively measurable. It avoids subjective assessment and the researcher's bias when comparing outputs to case data (Homer, 1996, 2012; Oliva, 2003; Martinez-Moyano and Richardson, 2013).

The outcomes of each subsystem are compared to their historical counterparts graphically. Through a graphical comparison, the model's ability to follow the same development path over time can be established (Barlas, 1996; Sterman, 2000). This graphical comparison allows the researcher to review the whole development of variables. Compared to aggregated, statistical measures of fit, this graphical approach provides additional information. For example, it may highlight the timing of errors and mismatches between model, theory, and case data. The modeller can trace and fix the causes of errors along causal links to problematic structures and equations (Homer, 2012; Martinez-Moyano and Richardson, 2013). These were then improved in the iterative modelling process.

2.4.2. Scenario simulation

After the developed model has been validated using case data, it can be used for simulations to test and evaluate different policies. Thereby, the model is used to simulate scenarios investigating the impact of alterations on the system's behaviour. Compared to experiments in the real world, these virtual simulations have the advantage of being cost-effective. They are also replicable because the model results depend entirely on the model inputs without interference from cofounding or other influences. Simulation modelling also reduces safety concerns and adverse effects for participants as experiments do not affect them in reality (Coyle, 2000; Sterman, 2000; Warren, 2002; Davis, Eisenhardt and Bingham, 2007; Harrison *et al.*, 2007). In this project, the development of value creation and capture under varying scenarios will be simulated. Setting up System Dynamics simulations requires constructing a base case and identifying the policy changes that are compared to the base case.

Firstly, simulation researchers must create a base case of initial conditions and parameters that serves as the foundation for later comparisons. Practitioners of System Dynamics modelling in companies might, for example, use the company's current conditions and policies as a base case. This base case approximates a company's future development if everything stays as it is now (Sterman, 2000; Warren, 2002). Simulation researchers might also create artificial, hypothetical base cases (March, 1991). While the former approach ensures that the base case is realistic, the latter approach can isolate and create optimal conditions for theoretical relevance. Davis *et al.* (2007) argue that simulation research should strive for realism and theoretical relevance. Therefore, this thesis combines both approaches by creating a hypothetical, idealised company as a base case. The case is inspired by details of the case companies and their data. It is constructed with theoretical implications for a typical company in mind. In addition, parameter values are evaluated for their realism compared to those found among the case companies during model validation.

Secondly, researchers must decide which policies to test in the model. In System Dynamics, two important types of policy changes can be observed. Firstly, policy changes might concern the numerical values of variables. For example, companies might employ new strategies. The model can reflect these through values for managerial targets, goals, priorities, and commitment levels. Secondly, policy changes might concern the structure of the model. In business contexts, such structure-affecting policy changes usually relate to management decision rules regarding, for example, which factors they consider when setting targets and implementing them. Modellers usually implement policy changes through Coyle's (1996, p. 106) 'policy switches'. These switches are variables set to either zero or one to activate or suppress certain parts of an equation (Coyle, 1996; Sterman, 2000; Warren, 2002; Harrison *et al.*, 2007). Both types of experiments are simulated using the model. Simulations will determine the effect of policy changes that change the model structure and the impact of different variable values within the same policy structure. These principles have been implemented to determine the structure of Chapter 6. Its sections are set based on different policy switches that cause different types of performance development. Within each section, policies related to numerical values are simulated.

2.4.3. Analysis of results

The analysis of simulation results focuses on value creation, the share of value captured, and financial resources as a cumulative performance measure. Each scenario has been analysed individually before comparing scenarios to synthesise answers to this thesis' research questions and aim.

Individual scenarios have been analysed by identifying behavioural patterns, the structures that cause the patterns, and the variables that affect structures. Firstly, the time-series graph for each performance outcome in a scenario has been analysed to identify development patterns. These patterns may align to patterns commonly observed in System Dynamics projects (Taylor, 1980). They include, for example, exponential growth, goal-seeking behaviour, s-curves, oscillation, and overshoots (Kim and Anderson, 1998; Sterman, 2000). Secondly, the model has been reviewed for the dominant structures that cause a scenario's performance development. For example, goal-seeking development requires a balancing feedback loop that becomes stronger over time (Kim and Anderson, 1998; Sterman, 2000). The identified structures are described to explain the observed patterns. It is best practice in System Dynamics modelling that the dominant structures are also included in the causal loops that conceptualise and provide an overview of the model (Martinez-Moyano and Richardson, 2013). In the iterative modelling process, it has thus been ensured that they are considered and represented when the model is conceptualised in Chapter 3. Lastly, the exogenous variables influencing these structures have been considered. For example, a goal-seeking loop requires a goal towards which a variable develops.

Scenario results, particularly the exogenous leverage points, have also been compared across scenarios to answer this thesis' research questions and achieve its aim. The development patterns, structures, and influencing variables have been compared across scenarios to identify leverage points that cause different patterns and the diversity within those patterns (Meadows, 1997, 2009). This allowed this thesis to identify answers to its research questions by categorising different development patterns and revealing the positive and negative impact of growth on value creation and the ability to capture value. The presentation of scenario results (Chapter 6) is structured to illustrate those similarities and differences. Each section of the chapter describes one development pattern with diverse developments within each pattern. While the first section illustrates the development of a company focused on exploiting its current size, the second section illustrates the development of a company striving to scale up. This presentation eases the identification of answers to the research questions presented in the introduction. The discussion derives answers to these research questions and derives a framework helping digital ventures develop an ability to capture value while growing their value creation. This framework and the answers to the research questions also draw from the other chapters and modelling steps. This information is used to describe the conceptualisations (Chapter 3) and formal structures (Chapter 4) causing development patterns, and illustrating them in historical case study development (Chapter 5).

Chapter 3: Theory integration and model conceptualisation

This chapter conceptualises the model used to investigate the development and relationships of value creation and capture for digital ventures. The chapter provides a strategic overview of the model utilising causal loop diagrams illustrating the mechanisms affecting value creation and the share of value captured. These causal loop diagrams synthesise and integrate growth paths theory, dynamic states theory, and their background literature. Their relevant elements are: value creation and value capture as two critical performance outcomes; the business model including its resources, activities, and capabilities; influences from the external environment and the dominant logic of managers and entrepreneurs (Figure 3-1). The diagrams in this chapter illustrate the systemic relationship between these elements.

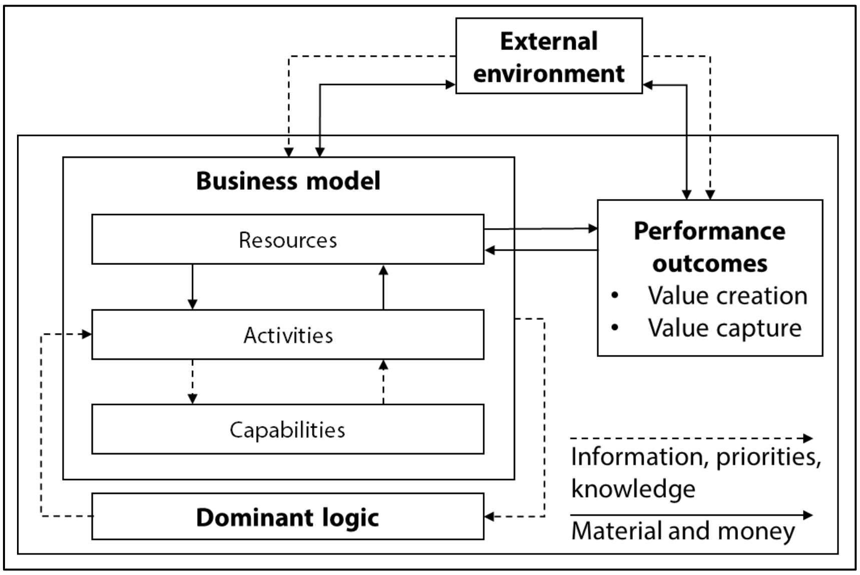


Figure 3-1: Overview of model elements

This first section conceptualises value creation and capture as the critical performance outcomes of this thesis. It then works backwards to identify the business model elements affecting performance outcomes, including resources, activities, and capabilities. This chapter then discusses influences on the identified relationships in the companies' environment and different dominant logics. As explained in the methodology chapter, the causal loop diagrams communicate how the growth process theories have been synthesised on a general and aggregated level. Thus, this chapter illustrates the dynamic processes affecting performance outcomes over time. The final section of this chapter analyses the conceptual model qualitatively to obtain insight about the development of value creation and the share of value captured. The diagrams conceptualised here serve as a guideline for the next chapter, where these general feedback processes are contextualised, specified, and formalised for digital ventures (Wolstenholme, 1999; Sterman, 2000; Morecroft, 2015; Kunc, 2017).

3.1. Performance outcomes

Companies need to create customer value and capture part of that value to generate resources during the growth process (Figure 3-2). Whereas *value creation* refers to the total amount of customer value created over a period of time, the *share of value captured* refers to the fraction of the created value that is received and maintained by a company as profit (Teece, 1986; Garnsey, Dee and Ford, 2006; Hull *et al.*, 2007; Lepak, Smith and Taylor, 2007; Davidsson, Steffens and Fitzsimmons, 2009; Levie and Lichtenstein, 2010; Zott and Amit, 2010; Huang *et al.*, 2017; Hsieh and Wu, 2019). Growth process theories build on the existing literature on value creation and capture to conceptualise these performance outcomes. Teece (1986) and Zott and Amit (2010) illustrate value creation and capture using a pie metaphor. The pie's size represents the value created by a company over a period, such as a financial year. However, a company only captures a part of that pie as profit. This part captured by the company represents the resources generated during the growth process. Customers and the firm's input providers capture the other parts of the pie.

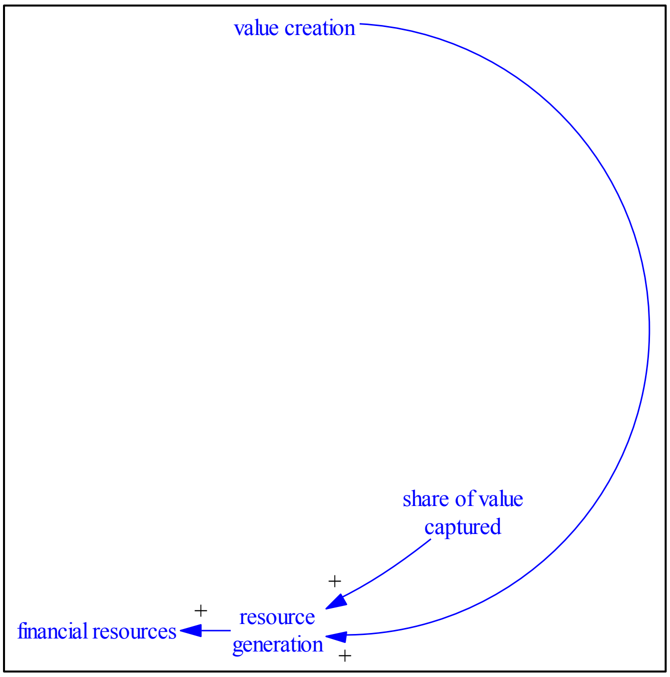


Figure 3-2: Resource generation

Both performance measures are critical to the continuity of the firm during the growth process. While growth paths theory focuses on capturing value and generating resources (Garnsey, 1998; Garnsey, Lubik and Heffernan, 2015), dynamic states theory stresses value creation (Levie and Lichtenstein, 2010). Both theories acknowledge that both performance outcomes - creating value and capturing part of that value - are required for *resource generation*. These generated resources accumulate as *financial resources*. In growth paths theory, these generated resources increase the company's size and provide the means for further investments (Garnsey, 1998; Stam and Garnsey, 2006; Garnsey, Lubik and Heffernan, 2015). In dynamics states theory, these resources ensure the viability of a growth state (Levie and Lichtenstein, 2010). Therefore, companies should maximise the resources they generate by growing the amount of value they create or increasing the share of value they capture. However, as pointed out in the introduction of this thesis, existing theory cannot explain why these two performance measures develop diversely and what relationships exist among these two outcomes (Sapienza *et al.*, 2006; Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009). The subsections below conceptualise the influences on value creation and capture. These influences are part of the venture's resources and external environment. Managers need to change them to maximise their value creation and share of value capture.

3.1.1. Value creation

Value creation is the generation of customer benefit by providing solutions to customer needs (Amit and Zott, 2001; Levie and Lichtenstein, 2010). It reflects the monetary amount of value that the company has created for all its customers during a period. The theories separate value creation into the volume of products or services rendered over a period and the use value of each unit of product or service. For example, companies selling physical products create value by providing a certain number of products per period, with each product unit having a specific value. This value per unit of product is also called use value. It refers to the amount of money at which a customer is indifferent between having one unit of the product or having the money. It is the maximum amount of money a customer is willing to pay for a product (Porter, 1985, 1991; Peteraf and Barney, 2003; Lepak, Smith and Taylor, 2007). The product's use value reflects the value created per unit of product. Therefore, the total monetary amount of value created by a company also depends on the number of units sold over the period of interest (Zott and Amit, 2010). One can decompose the value created by a service company similarly. It depends on the value created every time a venture renders a service and the number of times the company renders it over a period.

The resources in the venture's business model and factors in its external environment affect *value creation* (Figure 3-3). The volume of products or services rendered in a digital context depends on the venture's *customer and user base*. The formalisation chapter further distinguishes between these different types of customers. The *use value* depends on the venture's *product quality* and the *usage intensity* at which customers use the venture's product or service. The customer and user base and product quality are reviewed as resources in the business model. The usage intensity is an environmental factor reflecting the behaviour of customers and users regarding the product. Thereby, the model implements arguments of the resource-based view that companies need to provide valuable products to customers. However, the customer in the venture's environment assesses the value (Barney, 1991, 2001; Grant, 1991; Peteraf, 1993; Peteraf and Barney, 2003). In a digital context, this usage intensity changes through *feature adoption*. Customers learn more about a software product, use additional features and functionalities, and generate greater value from using the product over time. However, this adoption is limited to a maximum of available features and time (Afuah and Tucci, 2000; Amit and Zott, 2001; Harmon, Raffo and Faulk, 2004; DaSilva *et al.*, 2013; Haile and Altmann, 2016b).

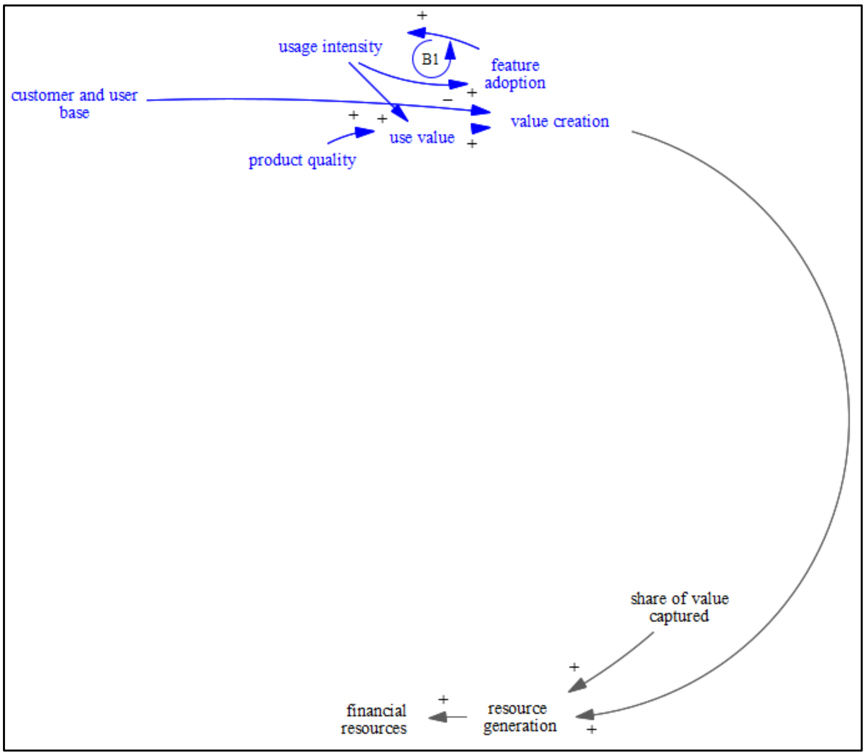


Figure 3-3: Value creation[6]

To maximise value creation, managers and entrepreneurs can thus alter their resource base or select more attractive environments. Companies can scale up their customer and user base to create value for more customers. They can also improve their product quality to generate more value for each user or customer (Lepak, Smith and Taylor, 2007; Garnsey, Lubik and Heffernan, 2015; Huang *et al.*, 2017). These two approaches form the basis for the managerial targets discussed as part of dominant logics discussed below. At a constant customer/user

[6] Elements considered in each section are highlighted in blue to allow the reader to follow the descriptions of the text in the diagrams. Parts introduced in previous sections are displayed in grey to build the model step by step.

base and product quality, value creation and resource generation will automatically develop towards a maximum through the balancing feedback loop of customers adopting features over time (B1). Companies can target users and customers that use the product more intensively and thus derive greater value from using it (Garnsey, 1998). Thereby, they reach a higher maximum of value creation or develop towards it more quickly.

3.1.2. Value capture

The created value presents "the overall size of the value pie" and the maximum value a company can capture. The share of value captured represents the fraction of the pie that a company receives and maintains as profit (Zott and Amit, 2010, p. 218). Within this metaphor, companies capture only part of the value they create for customers as revenue. Ventures also pass on some of the value to input providers as costs and expenses and they lose some value due to the erosion of resources (Nelson and Winter, 1978; Teece, 1986; Dierickx and Cool, 1989; Porter, 1991; Knott, Bryce and Posen, 2003; Lepak, Smith and Taylor, 2007; Zott and Amit, 2010). These three factors, and thus the *share of value captured*, depend on the resources of the venture and its external environment (Figure 3-4).

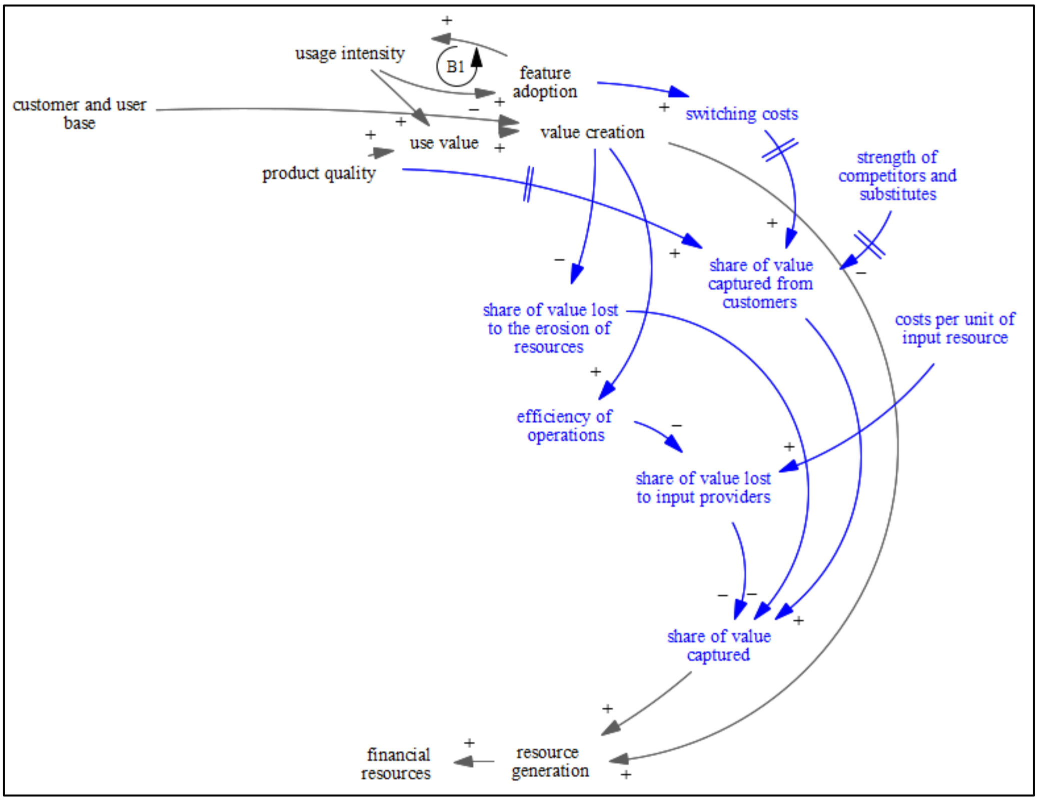


Figure 3-4: Share of value captured

Companies capture only part of the value they create for customers as revenue. While the total value created reflects customers' maximum willingness to pay, the actual price exchanged for a product or service is usually below this maximum willingness to pay. Customers capture the difference between their willingness to pay and the price as consumer surplus. The *share of value captured from customers* as revenue depends on the *product quality* as a resource relative to the *strength of competitors and substitutes* in the environment. A monopoly provider may be able to capture the entire use value created for customers. The product's price corresponds to customers' maximum willingness to pay in such cases. However, the availability of suitable alternatives from competitors and substitutes lowers the bargaining power to customers, forcing companies to lower prices. Thereby, companies capture a smaller fraction of value, while the consumer surplus increases (Porter, 1991; Peteraf and Barney, 2003; Garnsey, Dee and Ford, 2006; Lepak, Smith and Taylor, 2007). Moreover, as customers learn and adopt features of digital products and services, they develop *switching costs* that increase the bargaining power of the venture and allow it to capture more value (DaSilva *et al.*, 2013). However, due to contract terms that are common for digital products and services, effects on the share of value captured may be delayed (Harmon, Raffo and Faulk, 2004; Saaksjarvi and Lassila, 2005; Tyrväinen and Selin, 2011; Voigt and Hinz, 2016; Kohtamäki *et al.*, 2019).

Companies also lose value to input providers such as employees, suppliers, and investors. Through expenses, companies compensate input providers for their contribution to the production process. The *share of value lost to input providers* expresses these costs as a fraction of the value created. It depends on two factors: Firstly, the *efficiency of operations,* which reflects the venture's *value creation* per resource input. Secondly, the *cost per unit of input resource* in the external environment (Porter, 1985; Peteraf and Barney, 2003; Stam and Garnsey, 2006; Zott and Amit, 2007).

The venture may also lose resources due to the erosion of resources. During the process of value creation, the venture's resources erode due to their limited useful lifetime. For example, fixed assets depreciate and amortise. The *share of value lost to the erosion of resources* expresses these lost resources as a fraction of the *value creation* (Nelson and Winter, 1978; Dierickx and Cool, 1989; Porter, 1991; Knott, Bryce and Posen, 2003).

The causal loop diagram above separates the share of value captured into three fractions: the share of value captured from customers, the share of value lost to input providers, and the share of value lost to resource erosion. Variables in the external environment and the resource base affect these three fractions. Managers can alter them to maximise value capture. In the resource base, ventures can improve their product quality to improve their bargaining power to customers (Porter, 1985, 1991; Lepak, Smith and Taylor, 2007). They may also use resources more efficiently or over extended periods (Barney, 1991; Grant, 1991). In the environment, managers and entrepreneurs can select industries and business models with less competition and lower input costs (Porter, 1985, 1991; Lepak, Smith and Taylor, 2007). Moreover, they can target customers that develop greater switching costs (Porter, 1985). Improving the product quality, switching costs, and industry selection may affect value creation and capture simultaneously. Efficiency improvements affect only value capture. However, changes in the resource base and environment may not cause immediate improvements in the share of value captured due to contract times. Moreover, dynamic processes can be observed in this diagram. As customers adopt features (B1), switching costs increase, which improve the value captured from customers over time. Thereby, the share of value captured increases because the venture creates more value at equal input usage and resource erosion.

3.2. The business model and its elements

The business model defines the architecture used by a company that "creates and delivers value to customers, and then converts payments received to profits" (Teece, 2010, p. 173). Thus, a company's business model determines value creation and the share of value captured as the two central performance measures (Teece, 2010; Zott and Amit, 2010; Standing and Mattsson, 2016; Guo *et al.*, 2020). This relationship between the business model and the performance outcomes is acknowledged in growth paths theory (Hugo and Garnsey, 2002; Stam, Garnsey and Heffernan, 2006; Garnsey, Lubik and Heffernan, 2015) and dynamic states theory (Levie and Lichtenstein, 2010; Brown and Mawson, 2013; Gabrielsson and Gabrielsson, 2013; Ingley, Khlif and Karoui, 2017). Three different views exist in the literature on business models cited by growth process theories. One view conceptualises business models as activity systems or value chains, in which activities are the drivers of performance (Porter, 1991, 1996; McKelvey, 1999; Zott and Amit, 2010). The resource-based view argues that companies' performance depends on their resources and capabilities (Grant, 1996; Amit and Zott, 2001). The third view on business models sees them as the connecting mechanisms between the firm and its environment, with the place and position in that environment determining performance (Zott and Amit, 2007; Garnsey, Lubik and Heffernan, 2015). The concepts of resources, activities, and capabilities are central to growth paths theory, although the theory does not explicitly link them to the business model (Garnsey, 1998; Stam and Garnsey, 2006). Reflecting the elements identified in growth paths theory, this thesis considers the first two views – the activity systems and resource-based view – as providing the business model's elements. The environment as the third view of business models influences these elements and their relationships. The subsections below describe resources, activities, and capabilities as elements of the business model and note influences from the external environment where they are present. Such influences have already been identified when conceptualising the performance outcomes. For example, they include the strength of competitors and substitutes or the costs of resource inputs.

3.2.1. The impact of resources on performance outcomes

This thesis proposes that, at any point in time, value creation and capture as central performance outcomes depend on the company's resources and its external environment. Resources are tangible and intangible assets used or controlled by the firm for its operations (Barney, 1991; Grant, 1991, 1996; Teece and Pisano, 1994; Amit and Zott, 2001; Penrose, 2009). This thesis identifies five types of resources in growth process theories that directly affect value creation and capture (Figure 3-5). Moreover, some resources depend on secondary resources in a digital context.

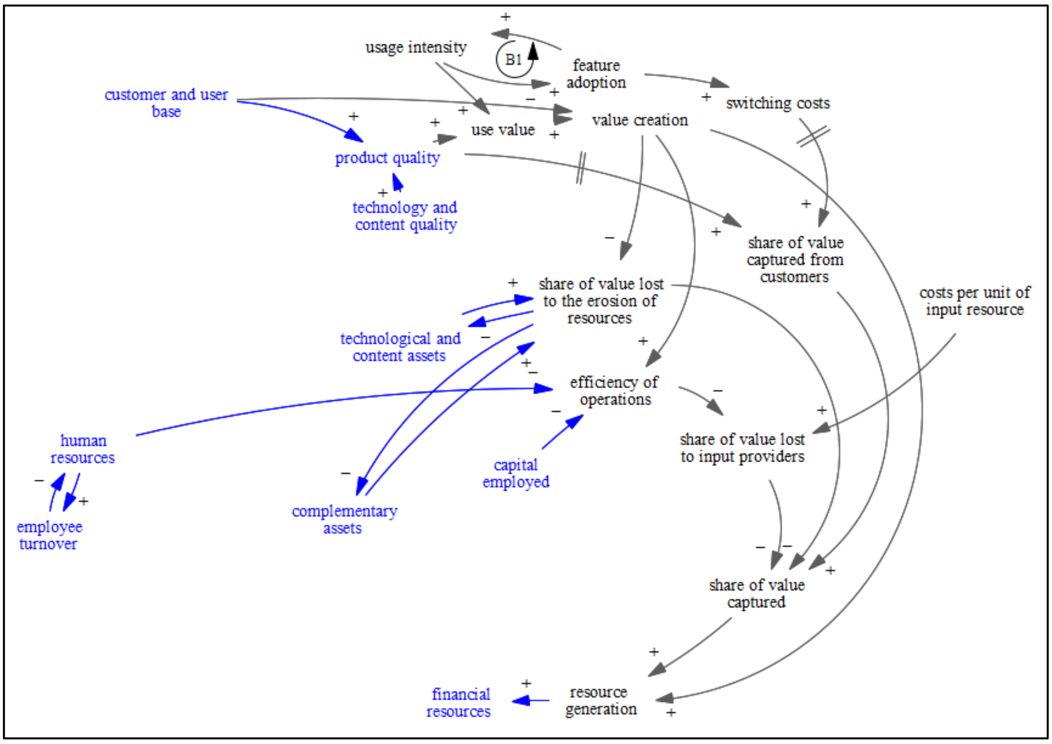


Figure 3-5: Resource-performance relationships

The above conceptualisation of value creation has already identified two resources affecting performance outcomes:

- The *customer and user base* reflects the number of customers and users serviced by a venture. A larger customer base provides additional demand and an outlet for the venture's product or service. Therefore, the larger this customer base, the more value the venture creates (Garnsey, 1998; Stam and Garnsey, 2006; Garnsey, Lubik and Heffernan, 2015). As further discussed in the next chapter, digital ventures may distinguish between customers, users, and premium users (Afuah and Tucci, 2000; Kollmann, 2006; Zott, Amit and Massa, 2011).
- The *product quality* also affects value creation through the use value. This quality usually depends on the quality of the product's technology and its features (Miozzo and DiVito, 2016; Hesse and Sternberg, 2017). However, digital ventures may also employ business models with additional value drivers. For example, digital ventures may create value using content. Their product quality thus depends on the quality of that content. The causal loop diagram above aggregates the *technology and content quality* because they develop through similar mechanisms. Other digital ventures employ business models with network effects. In such business models, the customer and user base is a driver of the product quality too (Zhu and Iansiti, 2007; Kim, Oh and Shin, 2010; Hamari and Keronen, 2017). The next chapter further discusses these business model design choices and value drivers.

A venture also requires resource inputs to create value and must compensate providers of resources. Economists generally distinguish between labour and capital as inputs for companies (Nelson and Winter, 1982). The model considers labour as human resources. It distinguishes between three different types of capital based on the views of innovation and strategic management scholars. These are the venture's technology and content assets, complementary assets such as equipment, and financial resources held as liquid funds (Teece, 1986; Grant, 1991; Garnsey, 1998; Penrose, 2009).

- *Technological and content assets* reflect the quantity of technological resources and content assets maintained by the venture. Technological resources may include, for example, intangible assets capitalised on its balance sheet. Content assets reflect the venture's content library, such as music, video, or written content available for users. Like their quality, these two types of assets are aggregated here. Once developed, they may amortise over time and increase the share of value lost to resource erosion (Nelson and Winter, 1978; Dierickx and Cool, 1989; Porter, 1991; Knott, Bryce and Posen, 2003).

- *Complementary assets* are resources required to commercialise a technology. Teece (1986, 1998) regards all resources and capabilities required to commercialise a technology as complementary assets. Growth paths theory focusses on, for example, equipment for production and customer service (Garnsey, 1998; Garnsey, Stam and Heffernan, 2006; Stam, Garnsey and Heffernan, 2006; Miozzo and DiVito, 2016). In a digital context, these might, for example, include hosting equipment and server capacity (Oliva, Sterman and Giese, 2003; Sterman *et al.*, 2007). Like the technological and content assets, complementary assets depreciate over time. Thus, they affect the share of value lost to the erosion of resources (Nelson and Winter, 1978; Dierickx and Cool, 1989; Knott, Bryce and Posen, 2003).
- *Human resources* reflect the firm's number of employees. These are critical for the growth process because they execute activities using other resources (Nelson and Winter, 1982; Garnsey, 1998; Penrose, 2009; Garnsey, Lubik and Heffernan, 2015). The more employees are required to execute the venture's activities, the lower the venture's efficiency, the higher the compensation paid to the input provider, and thus the higher share of value lost to input providers (Porter, 1985; Peteraf and Barney, 2003; Stam and Garnsey, 2006; Zott and Amit, 2007). Over time, the venture's human resources erode due to *employee turnover* (Hambrick and Crozier, 1985; Hamermesh and Pfann, 1996; Baron and Hannan, 2002; Garnsey and Heffernan, 2005).
- *Financial resources* refer to the company's cash position (Teece, Pisano and Shuen, 1997; Miozzo and DiVito, 2016). These resources provide the company with liquidity to invest in its activities and to compensate input providers. Financial resources also provide a buffer for shocks and miscalculations, such as drops in demand due to increasing competition or higher than expected costs (Garnsey, 1998; Garnsey and Heffernan, 2005;

Garnsey, Dee and Ford, 2006; Garnsey, Stam and Heffernan, 2006). Financial resources are generated through resource generation and by raising them from investors through the *capital employed*. This capital reflects the amount of money raised. Investors and lenders are compensated for their capital contribution. The more capital is employed to create a given amount of value, the lower the venture's efficiency and the higher the share value lost to input providers (Porter, 1985; Peteraf and Barney, 2003; Stam and Garnsey, 2006; Zott and Amit, 2007).

Resources are critical for the growth process besides their direct effect on value creation and capture. Penrose (2009) defines the growth process as a series of internal changes leading to a change in firm size. Growth paths theory builds on Penrose's conceptualisation of the firm (Garnsey, 1998; Stam, Garnsey and Heffernan, 2006). She defines the firm as "a pool of productive resources" (Penrose, 2009, p. 2). Because the firm is a collection of resources, its size is defined as the present value of its total resource (Garnsey, Dee and Ford, 2006; Stam, Garnsey and Heffernan, 2006; Penrose, 2009). However, one cannot calculate this present value accurately. Therefore, growth paths theory utilises other measures of resources to approximate a firm's size. These measures include, for example, total assets, fixed assets, capital raised, or the number of employees (Garnsey, 1998; Garnsey, Dee and Ford, 2006; Garnsey, Stam and Heffernan, 2006; Stam and Garnsey, 2006; Stam, Garnsey and Heffernan, 2006). Moreover, the internal changes occurring during the growth process refer to changes in the company's resource base. After starting with an initial resource base, the company's resources change continuously through exchange with the external environment and internal transformation (Garnsey, 1998; Stam and Garnsey, 2006; Miozzo and DiVito, 2016). Some of these dynamic changes in the company's resources as part of the growth process are already present in the above conceptualisation. For example, the complementary assets and human resources erode over time due to depreciation and turnover. Growth paths theory adds further that resources generated through creating value and capturing a part of that value increase the firm's financial resources (Garnsey, 1998; Stam and Garnsey, 2006; Garnsey, Lubik and Heffernan, 2015). Activities may then transform these financial resources (Garnsey, 1998; Stam and Garnsey, 2006).

3.2.2. Resource transformation through activities

Resources develop dynamically through depreciation, amortisation, and resource generation. Additionally, activities may affect them. Growth paths theory defines activities as tasks executed by the company’s human resources utilising other resources to alter the firm’s resource base (Garnsey, 1998; Hugo and Garnsey, 2001, 2002, 2005; Stam and Garnsey, 2006; Penrose, 2009; Garnsey, Lubik and Heffernan, 2015). Activities may alter the venture’s resource base by transforming one resource into another, mobilising resources from the external environment, or creating resources from scratch. Different types of activities can be identified through their impact on the venture’s resources (Warren, 2002). This thesis considers four different types of activities, which link to the above resources and have been identified in growth process theories (Figure 3-6).

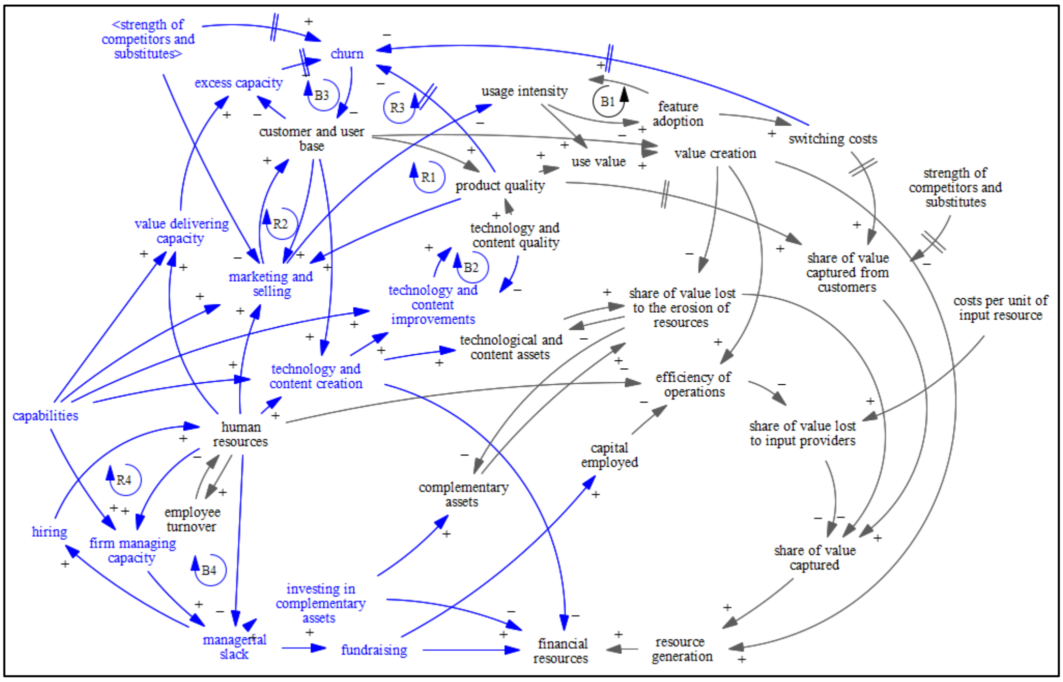


Figure 3-6: Resource development through activities

A first activity links to the venture’s technology and content. Ventures may create additional technological and content assets through *technology and content creation*. For many physical products, this takes the form of research and development, through which the venture’s employees add or improve product features. Thereby, the venture transforms financial resources into technological resources and content assets (Porter, 1991; Penrose, 2009; Garnsey, Lubik and

Heffernan, 2015; Miozzo and DiVito, 2016). In a digital context, employees and customers may also create content (Amit and Zott, 2001; Sahut, Iandoli and Teulon, 2019). This creation increases the venture's technological and content assets. Moreover, the creation may lead to *technology and content improvements* that affect the product quality. However, due to technology s-curves and limits to content quality, the higher the venture's existing technology and content quality, the lower the effect of creation efforts on the change in quality (Tidd, Bessant and Pavitt, 1994; Dosi, Nelson and Winter, 2000; Smith, 2015). This relationship creates a balancing feedback loop (B2) that limits growth in value creation and an increase in the ability to capture value over time through product quality improvements.

A second activity regards the development of the venture's customer and user base. Ventures acquire new customers and users through *marketing and selling*. The venture's human resources carry out marketing and selling depending on their capability level. Their effectiveness also depends on the product quality relative to competitors' products and substitutes (Garnsey, 1998; Bhide, 2000; Garnsey, Lubik and Heffernan, 2015; Hesse and Sternberg, 2017). A reinforcing feedback loop emerges in which the existing customers and users improve the product quality directly through network effects and indirectly though content creation, which in turn increases the acquisition of additional customers and users, who improve the product quality further (R1). Moreover, as discussed in the next chapter, digital ventures may rely more on word-of-mouth marketing than companies providing physical products. Through word-of-mouth marketing, the venture's existing users and customers acquire new users and customers, which in turn acquire more user and customers, creating another reinforcing loop (R2). Thus, the venture's marketing activities and customer/user recommendations drive the increase in the customer and user base (Mikalef, Giannakos and Pateli, 2013; Huang *et al.*, 2017).

Once acquired, digital ventures must deliver value to their customers and users. *Value delivering* in the context of physical products includes manufacturing. Digital ventures need to ensure the hosting of their website and service customers. Thereby, the venture's human resources provide the venture with a capacity to deliver value to customers and users. However, if the company cannot deliver value to its customers, customers might decide to drop the venture's product or service (Garnsey, Dee and Ford, 2006; Stam, Garnsey and Heffernan, 2006; Penrose, 2009; Gabrielsson and Gabrielsson, 2013; Miozzo and DiVito, 2016). This creates a balancing feedback loop in which insufficient capacity leads to higher churn, reducing the customer and user base towards the venture's capacity (B3). Moreover, customers and users may *churn* by switching to competitors' products. This churn depends on the switching costs of customers and users and the product quality relative to competitors and substitutes (Zhao, Song and Storm, 2013; Voigt and Hinz, 2016). This relationship may be delayed due to contract times employed by digital ventures and creates another reinforcing feedback loop. Like the acquisition of new customer and users through marketing and selling, the venture's larger customer and user base makes the product more attractive, reducing churn and helping to sustain the customer and user base (R3).

The last activity affects the venture's human resources and capital assets that the other activities utilise. Firm managing refers to the activities executed to oversee and expand the venture's operations. Its current managerial and administrative employees provide the venture with a *firm management capacity* utilised to manage and oversee the venture's existing employees. The firm's management is also responsible for planning and executing the venture's expansion through *fundraising, hiring*, and *investing into complementary assets*. The management executes these activities based on their priorities conceptualised as part of the dominant logic. However, the venture's management can only perform these activities when its capacity is not fully occupied with managing its existing human resources. In such cases, the venture has what growth process theories call *managerial slack*. This slack represents time available to plan and execute growth and expansion activities. The management's capability and its managerial slack constrain the venture's capacity to expand through hiring, fundraising, and investing. This limited capacity to grow the venture is critical to growth paths theory and is referred to as the Penrose effect (Garnsey, 1998; Hugo and Garnsey, 2001, 2002, 2005; Garnsey, Dee and Ford, 2006; Stam and Garnsey, 2006; Penrose, 2009; Garnsey, Lubik and Heffernan, 2015). The firm's ability to grow depends on the strengths of a reinforcing and balancing feedback loop determining managerial slack. On the one hand, the venture's existing human resources that require supervising reduce its managerial slack, inhibiting it to hire further (B4) and expand the firm. On the other hand, some of the firm's human resources are managers themselves who increase the venture's managerial capacity and allow it to grow the firm further including through additional hiring (R4).

3.2.3. Capability development

Besides human resources, the capabilities of employees also affect the outcomes of marketing and selling, value delivering, technology and content creation, and firm managing activities. This thesis defines capabilities as levels of productivity that determine the strength of the relationship between the venture's human resources and the effect of activities on resources. In growth paths theory, these productivity levels are achieved through the content of capabilities on an individual and organisational level. On an individual level, capabilities reflect the firm's employees' knowledge, skills, experience, and competence to execute activities. On an organisational level, these capabilities manifest in routines and processes which improve over time through learning, erode through hiring, and depend on the availability of sufficient complementary assets (Figure 3-7).

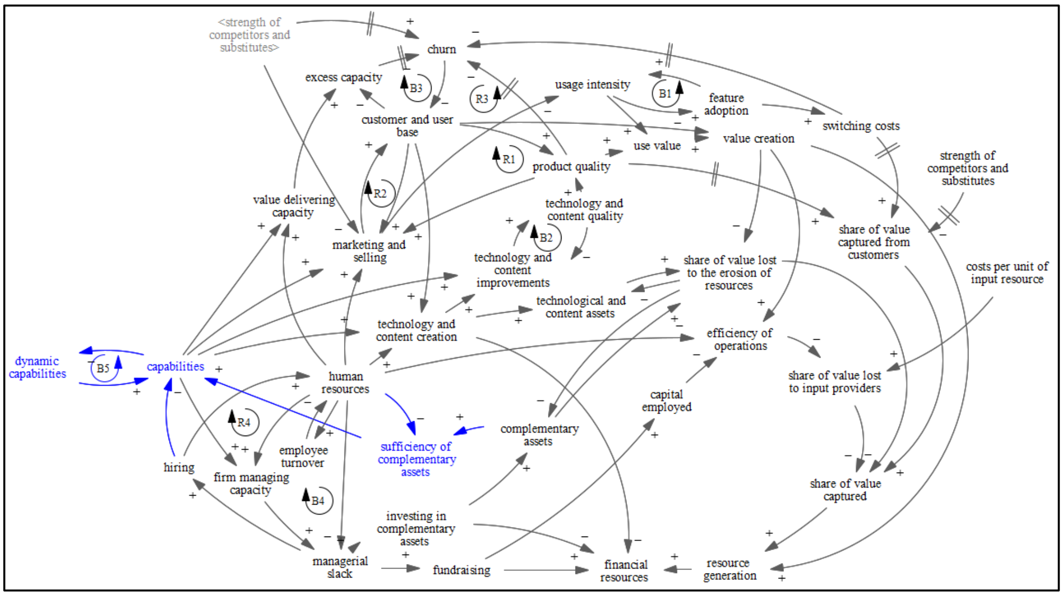


Figure 3-7: Capability development

In both growth process theories, capabilities improve over time through learning and routinisation (Garnsey, 1998; Hugo and Garnsey, 2005; Stam, Garnsey and Heffernan, 2006; Gabrielsson and Gabrielsson, 2013). Growth paths theory argues that new companies have not yet established efficient routines and processes. Instead, routines are experimental, and individuals are uncoordinated. However, capabilities improve as individuals accumulate experience working together and improve their routines and processes (Hugo and Garnsey, 2005; Stam and Garnsey, 2007; Garnsey, Lubik and Heffernan, 2015). Dynamic states theory also acknowledges such improvements through learning-by-doing (Gabrielsson and Gabrielsson, 2013). The rate of improvements depends on the firm's *dynamic capabilities*[7]. These are routines changing other routines and reflect the firm's "ability to change or reconfigure existing substantive capabilities" (Nelson and Winter, 1982; Nelson, 1995; Eisenhardt and Martin, 2000; Zott, 2003; Kor and Mahoney, 2004; Zahra, Sapienza and Davidsson, 2006; Gabrielsson and Gabrielsson, 2013, p. 1359). However, capabilities will develop towards a maximum through a balancing feedback loop (B5) because the higher the current level of capabilities, the lower the incentive to search for further improvements in knowledge and routines, and the more rigid the venture becomes. Therefore, the higher the firm's existing capabilities, the lower the firm dynamic capabilities (Porter, 1996; Dosi, Nelson and Winter, 2000; Eisenhardt and Martin, 2000; Bessant, Phelps and Adams, 2005; Bingham, Eisenhardt and Furr, 2007; Phelps, Adams and Bessant, 2007).

In addition to capability improvements, growth paths theory also highlights that mobilising additional resources, particularly human resources, harms capabilities. Routines and processes are firm-specific. Therefore, new employees lack a complete understanding of their specific role in routines (Fransman, 1994; McKelvey, 1999; Dosi, Nelson and Winter, 2000; Kor and Mahoney, 2004; Chiles, Bluedorn and Gupta, 2007; Federico and Capelleras, 2015). Thus, new

[7] A range of different definitions of dynamic capabilities exists in the literature. For example, some define dynamic capabilities as all capabilities that alter the resource base or as reflecting the firm's ability to adjust to the environment. Please see Zahra, Sapienza and Davidsson (2006) for a comprehensive review and list of definitions. The definition of dynamic capabilities as measures of change in substantive capabilities has been selected due to its consistency with the role of capabilities as productivity measures depending on individuals' knowledge and organisational routines.

employees are generally less productive than employees with experience in the firm. Hiring new employees reduces the average capability of the firm until new employees have gone through the same learning process that existing employees have gone through (Slater, 1980; Garnsey, 1998; Tan and Mahoney, 2005; Stam, Garnsey and Heffernan, 2006; Penrose, 2009; Miozzo and DiVito, 2016; Harbermann and Schuilte, 2017).

Lastly, dynamic states theory and the resource-based view highlight that capabilities also rely on the venture's resources (Grant, 1991; Peteraf and Barney, 2003; Gabrielsson and Gabrielsson, 2013). More specifically, growth paths theory points towards the importance of holding adequate complementary assets. A venture with more human resources requires more complementary assets to equip those employees (Garnsey, 1998; Stam, Garnsey and Heffernan, 2006). If the venture's complementary assets are insufficient for its human resource to carry out their tasks, capabilities as productivity measures fall (Garnsey, 1998; Stam, Garnsey and Heffernan, 2006; Gabrielsson and Gabrielsson, 2013).

3.3. Influences on the performance outcomes and business model

The dominant logic and external environment have been identified as influences affecting the performance outcomes and the business model. While some of these influences expand the model through additional feedback loops, other variables affect the causal loops without being affected by the feedback processes themselves. The subsections below describe these environmental factors and dominant logic.

3.3.1. Environmental influences

The environment affects ventures' performance outcomes by altering its ability to create value and capture a part of that value directly and indirectly (Garnsey, 1998; Hugo and Garnsey, 2005; Levie and Lichtenstein, 2010; Brown and Mawson, 2013; Ingley, Khlif and Karoui, 2017). The resource-based view and the activity-systems view on business models have been utilised to identify the business model's elements. The third view on business models conceptualises it as linking the company to its environment. In this view, a company's performance is affected by its position in its environment (Zott and Amit, 2007; Garnsey, Lubik and Heffernan, 2015). Growth paths theory conceptualises this environment as different groups of stakeholders that affect and are affected by the company (Garnsey & Heffernan, 2005; Garnsey, 1998). Following this conceptualisation, one can already identify influences from three stakeholder groups in the environment (Figure 6-7). Firstly, users and customers who generate use value based on their usage intensity. They may also contribute to value creation through product improvements and network effects. Secondly, input providers that the venture compensates for their human resources and capital through costs and expenses. Thirdly, competitors and substitutes who affect the venture's bargaining power and ability to acquire and hold on to customers. The detailed descriptions of the model in the next chapter discuss providers of complementary products as a fourth stakeholder group. The detailed model also includes a range of exogenous variables for each stakeholder group that determine the strength of the group's influences. These being exogenous effects is consistent with dynamic states theory, which considers the environment as given and the firm as adapting to its environment (Levie and Lichtenstein, 2010; Brown and Mawson, 2013). Thereby, these exogenous elements are a contextual influence that determines a venture's growth state. They allow some parts of the environment to change continuously (e.g. the user and customer base in the above model), while others change only with a growth state (e.g. costs per unit of resource input).

3.3.2. Dominant logic of managers and entrepreneurs

The dominant logic of managers and entrepreneurs determines expansion activities and drives resource allocation decisions. It reflects managers' and entrepreneurs' aspirations, beliefs, and decision-making logic (Prahalad and Bettis, 1986; Von Krogh, Erat and Macus, 2000; Levie and Lichtenstein, 2010). This decision-making logic adds additional feedback mechanisms to the model that determine the extent of hiring, fundraising, and investments into complementary assets based on managerial targets (Figure 3-8). As in dynamic states theory, these managerial targets reflect the exogenous part of the dominant logic. They affect the growth process from the outside (Levie and Lichtenstein, 2010). The venture forms targets that direct its firm management activities depending on these exogenous influences and its current resources and capabilities. This process takes place in three steps described below.

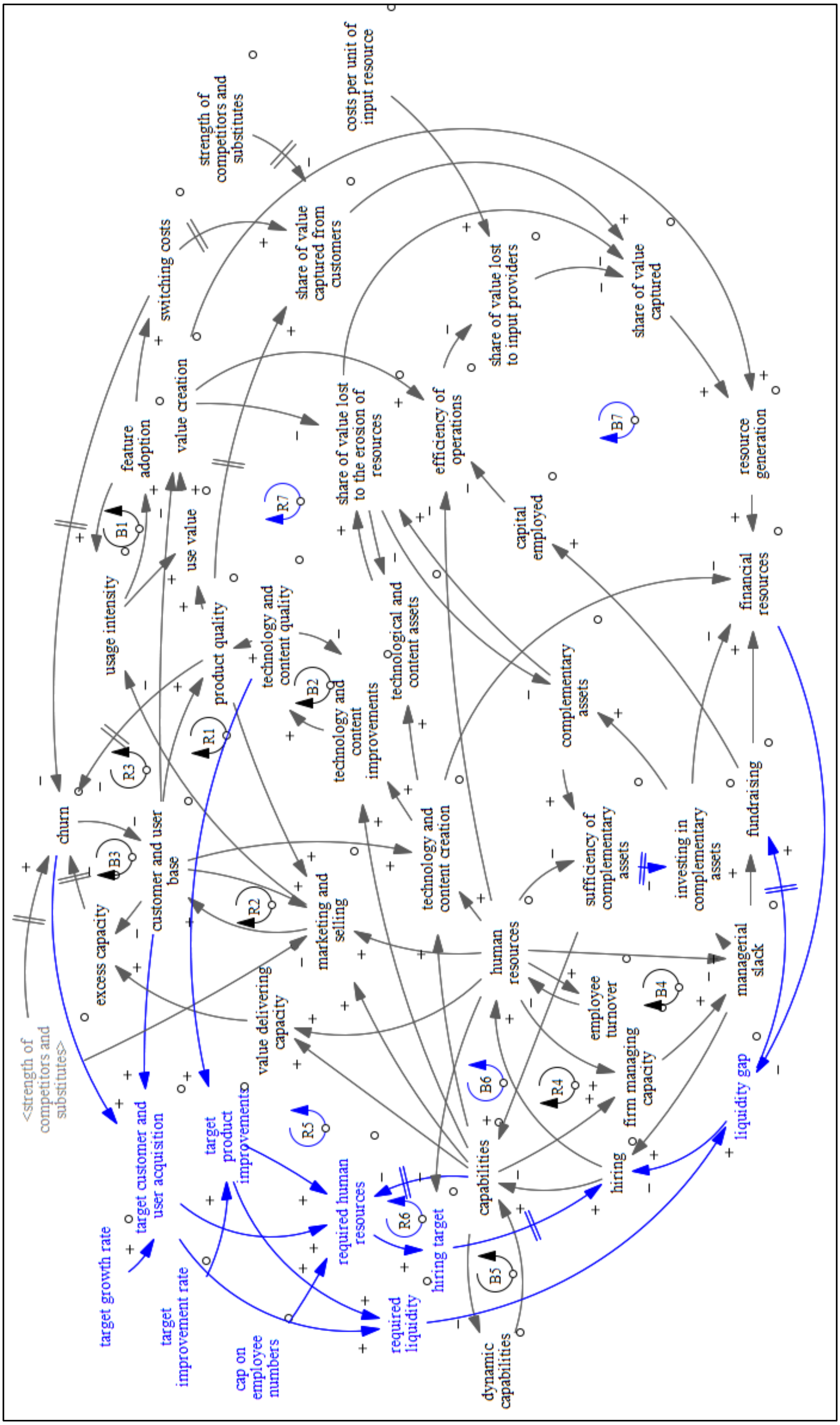


Figure 3-8: Impact of the dominant logic

Firstly, the venture's management determines the magnitude of targeted change in its resource base. This magnitude depends on its current resource stocks and the exogenous managerial targets. As outlined in the value creation subsection, digital ventures may create more value by improving their product quality and by increasing their user and customer base (Lepak, Smith and Taylor, 2007; Garnsey, Lubik and Heffernan, 2015; Huang *et al.*, 2017). Thus, ventures need to increase either or both resources stocks to increase value creation. The *target customer and user acquisition* represents the number of customers and users the venture aims to acquire within one year. The management determines it based on the current *customer and user base* and the *target growth rate.* It must also make up for customers it expects to lose through churn. Similarly, the venture determines its *target product improvements* through the current *product quality* and the *target improvement rate*.

Secondly, the venture's management determines the human resources and liquidity required to finance these acquisition and improvement targets. The higher the acquisition and improvement targets, the higher the *required liquidity* for recruitment, customer acquisition, development costs, and content creation (Garnsey, 1998; Miozzo and DiVito, 2016). Similarly, the higher the acquisition and improvement targets, the higher the *required human resources* at the venture's current capability levels (Harbermann and Schuilte, 2017). Here, two different types of dominant logic can be identified (Hesse and Sternberg, 2017):

- Some ventures restrict their human resources to a *cap on employee numbers*. Such entrepreneurs may be unwilling to accept the risks that come with growth or are comfortable with the current size of their companies. For example, because it provides them with an adequate return and covers their living expenses. Through a cap on employee numbers, they may maintain a company they can manage and stay in control of (Davidsson, 1989; Garnsey, 1998; Hesse and Sternberg, 2017).
- Other managers and entrepreneurs aim to grow their companies continuously and regardless of employee numbers. They may grow their customer base because they believe in their product and services, the existence of an even larger market, and their companies' ability to benefit from it (Schumpeter, 1928; Kotter and Sathe, 1978; Eisenhardt and Schoonhoven, 1990; Stuart and

Abetti, 1990; Fransman, 1994; Nicholls-Nixon, 2005; Steffens, Davidsson and Fitzsimmons, 2009; Hansen and Hamilton, 2011; Huang *et al.*, 2017). In such cases, the employee numbers depend on the targets that the venture strived to achieve and its capabilities. They are not capped to a maximum.

Lastly, the management needs to determine the gap between its target and current human and financial resources. It then mobilises resources to eliminate the difference and acquires sufficient complementary assets. The venture's current *financial resources* provide it with the means for further investments. If its current resources are below its *required liquidity*, the venture has *a liquidity gap* to fill through fundraising. Similarly, if its current *human resources* are below the *required human resources*, the venture forms a *hiring target* and closes the difference between current and target employee numbers (Sterman, 2000; Oliva, Sterman and Giese, 2003). The venture will also *invest in complementary assets* to equip the new employees sufficiently (Garnsey, 1998; Stam, Garnsey and Heffernan, 2006). Two factors may delay these activities. Firstly, they require managerial slack, which the activity section has discussed. Secondly, the management may delay hiring until the liquidity gap has been closed (Garnsey, 1998; Garnsey and Heffernan, 2005).

This three-step process of determining growth and improvement targets, identifying human resources and liquidity requirements, and closing gaps creates three feedback loops. Firstly, the process of closing the gap between targets and actual resources form balancing feedback loops. For example, the hiring target is reduced as the human resources increase through hiring (B6). However, hiring also reduces capabilities, which managers consider when determining hiring targets. With lower productivity levels, they will hire more employees in the next iteration, forming a reinforcing feedback loop (R5). Moreover, the hired human resources will grow the venture's customer base and improve its product. Thereby, goals and targets continuously shift upwards, requiring more employees in the next iteration, creating a reinforcing feedback loop (R6).

Dynamic states theory proposes that companies will maintain a dominant logic throughout a growth state (Levie and Lichtenstein, 2010; Brown and Mawson, 2013; Ingley, Khlif and Karoui, 2017). Similarly, scholars related to growth paths theory argue that goals, aspirations, and decision rules are maintained over periods of time (Nelson and Winter, 1982; Hambrick and Crozier, 1985; Nelson, 1995; Lockett and Thompson, 2004). Therefore, the target rates and caps on employee numbers are assumed to be constant during a growth state and exogenous to the system.

3.4. Implications for growth process and performance development

The above conceptualisation has implications for our understanding of growth states and the performance development within them. A qualitative analysis of the causal loop diagrams can derive these insights. Below, implications for the identification of growth states and two types of dominant logic are identified. The continuous change in value creation and capture is then outlined. This section then combines these different views from the respective theories. Thereby, this thesis argues that the performance development of companies depends on the type of growth state employed by a venture.

3.4.1. Implications for growth states

Dynamic states theory conceptualises the growth process as a process punctuated by transitions between growth states. Within a growth state, some elements of the company remain constant and unchanged. These elements change periodically when the firm changes its growth state (Levie and Lichtenstein, 2010; Brown and Mawson, 2013). The causal loop diagrams above outline exogenous variables that change with a growth state. They regard the venture's environment and its dominant logic. Therefore, a growth state can be defined by the variables that reflect the environment and dominant logic. The firm's external environment and the managers' dominant logic remain the same within a growth state. A change in these exogenous variables is discontinuous and indicates a change in a growth state.

These models' exogenous variables provide managers with two options to affect their firm's development and performance. First, managers and entrepreneurs select their environment (Garnsey, 1998; Levie and Lichtenstein, 2010; Brown and Mawson, 2013). For example, companies can target customers that realise greater value from their products or services. They may also position themselves in a niche with less competition or select input providers with lower bargaining power. Second, managers can pursue different targets with different employee limits. These resource allocation decisions alter the quantity and quality of resources in its business model over time (Prahalad and Bettis, 1986; Von Krogh, Erat and Macus, 2000; Levie and Lichtenstein, 2010). Formal modelling in the next chapter also uncovered other influences regarding capability development and the business model design. These are assumed to remain constant during a growth state like the environment and dominant logic.

While infinitely many growth states can exist, all growth states fall into two types. Levie and Lichtenstein (2010, p. 335) argue in their seminal contribution to dynamic states theory that there are infinitely many growths states. They derive this conclusion because the business model, which the dominant logic determines, and the environment can each manifest in infinitely many ways. The model can reflect this. For example, the venture’s costs for its input resources in the environment can take any positive value. Similarly, ventures can pursue any growth rate and adapt their business model elements accordingly. However, despite infinite possibilities, two essential differences regarding growth states can be observed: managers and entrepreneurs that want to grow with and without hiring more employees (Hesse and Sternberg, 2017). While the former operates at their cap on employee numbers, the latter is operating below or without a cap on employee numbers.

3.4.2. Continuous change within a growth state

Unlike dynamic states theory, growth paths theory conceptualises the growth process as a continuous resource and capability accumulation process (Garnsey, 1998; Garnsey, Stam and Heffernan, 2006). This chapter has reviewed growth paths theory and dynamic states theory to define and conceptualise value creation, value capture, and business model elements. These elements are endogenous to the model, meaning that they change continuously as part of the feedback processes considered in the model (Sterman, 2000). The feedback loops above illustrate these endogenous feedback processes. Performance outcomes and business model elements in the model develop dynamically. For example, the performance outcomes at any point in time depend on the quantity of resources in the business model and their value in its environment (Teece and Pisano, 1994; Garnsey, 1998; Stam and Garnsey, 2006). Creating value and capturing part of that value generates resources that increase the firm's resources. Therefore, the relationship between resources and performance outcomes is bidirectional (Garnsey, 1998; Stam and Garnsey, 2006). Through activities, which utilise resources, the firm alters its resource base (Hugo and Garnsey, 2005; Stam and Garnsey, 2007). The effectiveness of activities in altering resources depends on employee capabilities which develop through learning and destruction when executing activities (Hugo and Garnsey, 2005; Stam and Garnsey, 2006; Garnsey, Lubik and Heffernan, 2015; Miozzo and DiVito, 2016). The company needs to maintain a balance of the different types of resources within the resource base to prevent the impairment of capabilities and achieve its growth and improvement targets (Grant, 1991; Garnsey, 1998; Peteraf and Barney, 2003; Stam, Garnsey and Heffernan, 2006; Gabrielsson and Gabrielsson, 2013). These processes cause continuous change among the business model elements and the performance outcomes. They reflect resource and capability accumulation processes that growth paths theory considers the essence of the growth process (Garnsey, 1998; Stam and Garnsey, 2006).

3.4.3. Performance development in different growth states

The views of dynamics states theory and growth paths theory are complementary. This section has argued that two types of growth states exist regarding companies operating at or below their cap on employee numbers. It has also outlined the continuous changes in performance development and business model elements. Together, these two insights have implications for the performance development of companies. The dynamics among the business model elements and performance outcomes are different depending on the venture's type of dominant logic.

This thesis proposes that companies operating at their cap on employee numbers can improve their performance outcomes up to a maximum. In the above causal loop diagrams, companies can grow the value they create. Their existing employees will acquire new customers and improve the product. With increasing value creation and capped inputs, the share of value captured by such ventures will also continuously improve. Companies might even increase their growth rates in value creation due to increasing capabilities (B5). However, companies that want to maintain their current human resources are constrained by a maximum amount of value creation. Due to its value delivering capacity, companies will lose new customers that they cannot service adequately (B3). This capacity cannot be expanded by utilising productivity improvements due to the limitations of capability development (B5). Moreover, the technology s-curve prevents the product from being improved endlessly (B2). Due to these limitations, companies operating at their employee cap will eventually reach a maximum amount of value creation. At constant inputs, the share of value captured will also reach a maximum level. How quickly ventures will reach their respective maximums depends on the activities and capabilities and the idle potential of the venture. Examples of the former include the rate of acquiring customers and developing technology. Examples of the latter include possible capability improvements, its idle value delivering capacity, or remaining product improvements.

Those maximum levels do not constrain companies operating below or without a cap on employee numbers. Instead, such companies continuously increase the rate at which they acquire and service customers and develop their technology. These factors allow such ventures to increase the value they create continuously. However, a qualitative analysis of the causal loop diagrams above does not allow for hypothesising about the development of the share of value captured. On the one hand, the venture’s increasing value creation should also increase the share of value it captured. Digital ventures’ value creation and ability to capture value increase as it hires more employees who grow its customer and user base and improve its product. The resource generated through additional value creation can then be reinvested and reduce the liquidity gap that is filled before further growth (R7). However, on the other hand, the venture continuously increases the resource inputs for its activities through hiring, reducing its share of value captured, and the resources generated. Thus, fewer resources are available for reinvestment and the liquidity gap that requires closing before additional hiring increases (B7). However, the performance development of a case company depends on the relative strengths of the reinforcing and balancing feedback loops. Therefore, a qualitative analysis is insufficient to evaluate if the share of value captured remains fixed, falls, rises, or incurs more complex patterns.

These limitations of the qualitative analysis also apply to other important aspects. Firstly, the performance development taking place when companies change between the two growth states is unknown. While companies may grow, they will eventually need to reduce their growth rates and transition to an employee-capped dominant logic. Secondly, the impact of environmental factors and managerial targets requires investigation. The same applies to the additional exogenous, contextual variables uncovered in the next chapter regarding the venture's business model design and capability development. Simulation can determine the development of performance outcomes for individual companies (Chapter 5) and hypothetical scenarios (Chapter 6). Moreover, they can evaluate the transitions between growth states and the impact of other influences like the environment and business model design (Sterman, 2000; Warren, 2002; Morecroft, 2015). Therefore, the next chapter will utilise the literature on digital ventures to specify the mechanisms conceptualised in this chapter. It will formalise a simulation model that can be tested and simulated for case companies and hypothetical scenarios.

Chapter 4: Theory contextualisation and model formalisation

The previous chapter has integrated growth paths theory and dynamic states theory to identify the mechanisms affecting value creation and capture. It has also derived insights regarding the development of value creation and capture from the causal loop diagrams. For example, it hypothesised that companies that cap their employee numbers would approach maximum values for their value creation and share of value captured. A formal model and its simulation can test this qualitative analysis. They can also provide further insight regarding the balance of feedback loops for companies without employee limits. This chapter uses stock-and-flow diagrams to illustrate such a formal model and explain its equations. As argued in the methodology section, this chapter thereby provides a more detailed version of the model. The additional details provided here adapt and specify the model for the digital context. The chapter illustrates this detailed model in six subsystems (Figure 4-1).

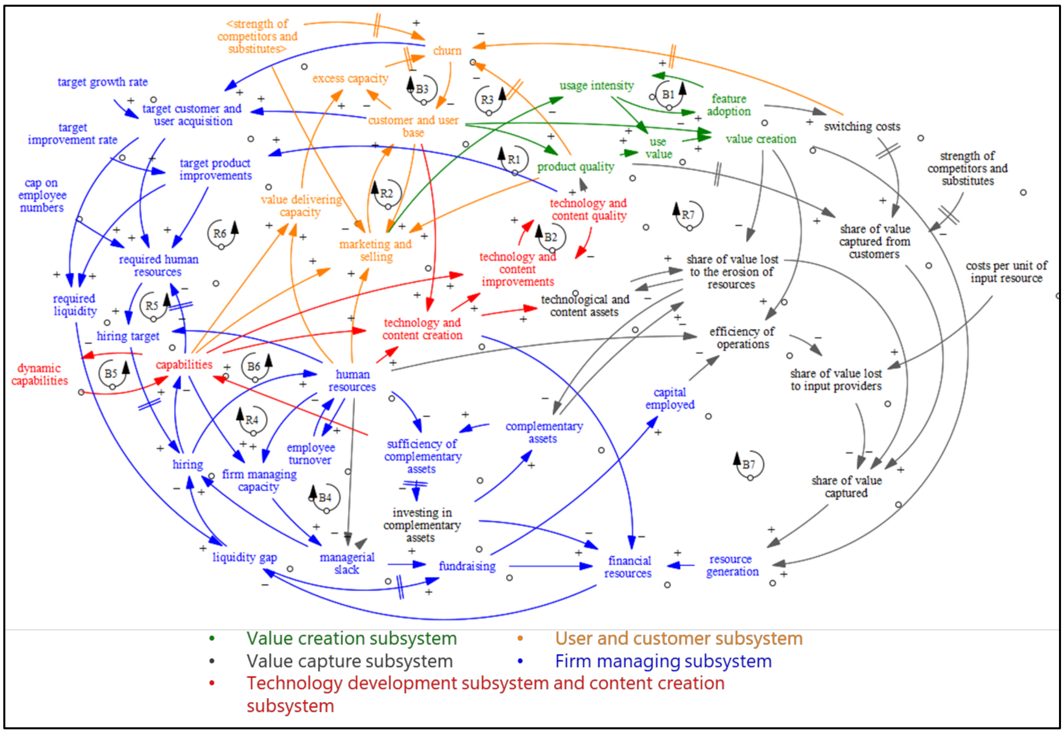


Figure 4-1: Model subsystems

The first two sections of this chapter focus on the value creation and capture subsystems. They contextualise the performance outcomes for digital ventures. As conceptualised in the previous chapter, the influences on these performance outcomes are traced back to variables in the environment and the venture's resources. The subsequent three sections focus on subsystems regarding different parts of the business model. The technology development subsystem and content creation subsystem[8] drive product improvements and determine the technological resources and content assets. The customer and user subsystem determines the venture's customer and user bases. The firm managing subsystem determines the venture's human resources and capital assets. The resource outcomes of those business model subsystems are inputs to the performance outcome subsystems. As conceptualised in the previous chapter, these subsystems are affected by the venture's environment and dominant logic. Moreover, this chapter identifies additional exogenous variables defining a growth regarding capability development and business model designs.

4.1. Value creation subsystem

This section traces the influences on a digital venture's value creation back to the outputs of the customer and user, technology development, and content creation subsystems (Figure 4-2). The subsystem highlights the external influences from customers and complementary providers that affect value creation. It also considers the business model design choices that affect value creation. Finally, the subsystem derives revenue as an accounting performance measure used to validate the model using a variable from the value capture subsystem.

[8] This thesis developed the content creation subsystem based on the literature on digital ventures. None of the identified case companies employs a content-based business model and the subsystem operates similar to the technology development subsystem. Therefore, the details of the content creation subsystem are illustrated in Appendix A.

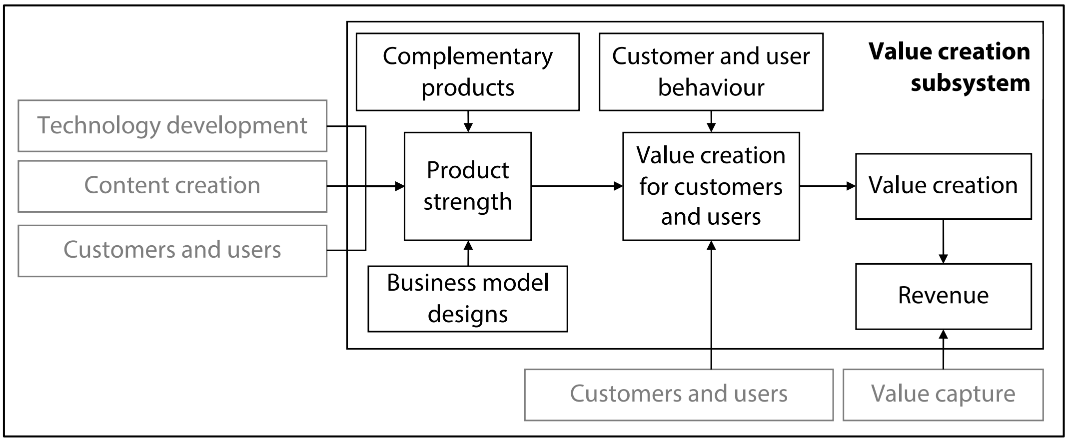


Figure 4-2: Value creation subsystem

This section adapts the conceptualisation of value creation for digital ventures. It distinguishes different customer groups, alters the attachment of the use value to units of the product, considers different value drivers, and recognises the changing usage intensity. The overall argument of model conceptualisation that performance outcomes are dependent on the venture's resources and environment is maintained.

4.1.1. Separating value creation for different users and customers

While customers of many physical products and services are homogenous, some digital ventures such as marketplace or social networks may distinguish between users and customers (Afuah and Tucci, 2000; Kollmann, 2006; Zott, Amit and Massa, 2011). Other digital ventures, such as some software-as-a-service (SaaS) companies, may further distinguish between users and premium users who generate different amounts of value from a product or service (Teece, 2010; Roma and Dominici, 2016; Voigt and Hinz, 2016; Möller *et al.*, 2020). Because digital ventures provide different types of services to these customer and user groups, the value created for them needs to be distinguished (Figure 4-3).

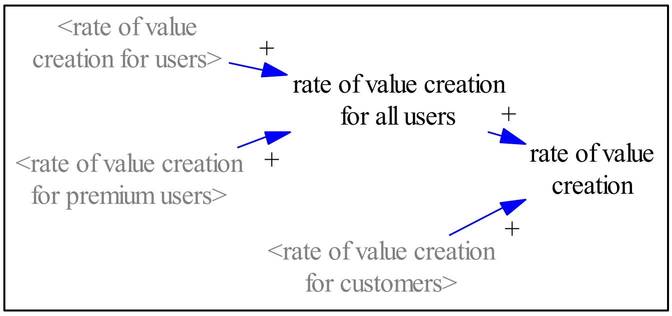


Figure 4-3: Value creation for users and customers

The model calculates a digital venture's *rate of value creation* by combining the *rate of value creation for all users* and the *rate of value creation for customers* (Equation 4-1). It separates the rate of value creation for all users further into the *rate of value creation for users* and the *rate of value creation for premium users* (Equation 4-2). Each value creation rate represents how much value a venture generates for the respective customer and user group in monetary amounts per year.

$$\text{rate of value creation} = \text{rate of value creation for all users} + \text{rate of value creation for customers} \qquad \text{Eq 4-1}$$

$$\text{rate of value creation for all users} = \text{rate of value creation for users} + \text{rate of value creation for premium users} \qquad \text{Eq 4-2}$$

The actual monetary amount that reflects customers' maximum willingness to pay is unknown and cannot be accurately measured (Forrester, 1984; Sterman, 2015; Haile and Altmann, 2016b, 2016a). Therefore, the model treats the rate of value creation as an indexed qualitative variable. At the beginning of the simulation, the rate of value creation has a value of one. Thereby, analysts can easily assess the growth in value creation without knowing the exact monetary amount. For example, a measure of 110 after one year of simulations indicates a 10% growth.

4.1.2. Value creation for each customer and user type

A second difference in the digital context concerns the attachment of the use value to units of products. Firstly, units of products cannot be easily identified and defined due to the openness of digital products and services (Lyytinen, Yoo and Boland, 2016; Nambisan, 2017; Nambisan, Lyytinen and Majchrzak, 2017). Secondly, the size of the venture's customer and user bases, not the rate at which products are sold and shipped, is a critical component of digital ventures' strategies and driver of value creation (Huang *et al.*, 2017; Kelestyn, Henfridsson and Nandhakumar, 2017; Zaheer *et al.*, 2019). Lastly, digital ventures may not generate value per unit of product but per period of time. For example, SaaS companies usually offer subscriptions to their software products. Users generate value from these over the period during which they use the software (Afuah and Tucci, 2000; Harmon, Raffo and Faulk, 2004; Haile and Altmann, 2016b; Gu, Kannan and Ma, 2018). Therefore, the value created for customers depends on the number of customers and the rate at which value is created for the average customer (Figure 4-4)[9].

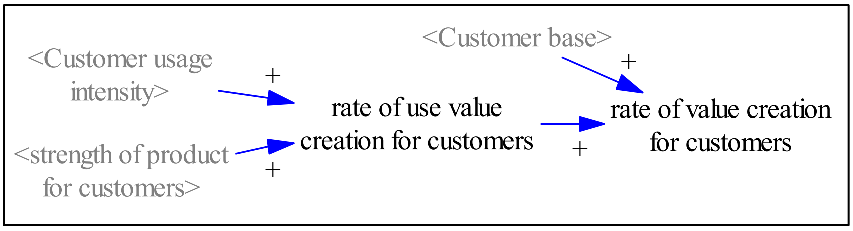


Figure 4-4: Rate of value creation for customers

The model calculates the rate of value creation for customers by multiplying together the *customer base* and the *rate of use value creation for customers* (Equation 4-3).

$$\begin{aligned}\text{rate of value creation for customers} \\ = \text{Customer base} \\ * \text{rate of use value creation for customers}\end{aligned} \qquad \text{Eq 4-3}$$

[9] The figure and the remainder of this section describe mechanisms for customers. The mechanisms are also applied and adapted to determine the value created for users and premium users. Appendix A provides these additional model details.

The rate of customer use value creation is a qualitative variable that reflects how much monetary value is generated from the product by the average customer. The model formalises the conceptualisation of the previous chapter by multiplying together the *strength of product for customers* and *customer usage intensity* (Equation 4-4). Each of these variables has an initial value of one to index value creation.

$$\begin{aligned} &\text{rate of use value creation for customers} \\ &\qquad = \text{Customer usage intensity} \\ &\qquad * \text{strength of product for customers} \end{aligned} \qquad \text{Eq 4-4}$$

The following two subsections describe the product's strength in a digital context and the customer usage intensity. The customer base is an outcome of the customer and user subsystem.

4.1.3. Value drivers determining the product strength

The strength of physical products depends on their features, such as their technological performance (Lepak, Smith and Taylor, 2007). However, digital ventures may rely on a broader range of factors contributing to value creation (Afuah and Tucci, 2000; Amit and Zott, 2001; Kollmann, 2006; Doganova and Eyquem-Renault, 2009; Huarng, 2013; Ojala, 2016; Kraus *et al.*, 2018). These value drivers "refer to any factor that enhances the total value created by an e-business" (Amit and Zott, 2001, p. 494). This thesis has identified five value drivers by synthesising the literature on digital business models. Each may contribute to the quality of a venture's offer for its users and customers:

- *Technological quality*: A venture's product or service is underpinned by its technology in the form of software code. Digital ventures can improve their technological quality through further development by adding features, improving reliability, or improving the ease-of-use of the technology (Wernerfelt, 1984; Bontis and Chung, 2000; Amit and Zott, 2001; Arora, Fosfuri and Gambardella, 2001; Teece, 2007; Clarysse, Bruneel and Wright, 2011; Haile and Altmann, 2016b; Hamari and Keronen, 2017; Nambisan, 2017).

- *Content quality*: Some digital ventures may sell digital artefacts to their customers and users or provide access to them. Examples include newspaper articles, music, or videos. The higher the quality of these content items, the more value is created for users consuming them (Kim, Oh and Shin, 2010; Bradley *et al.*, 2012; Naldi and Picard, 2012; Kallinikos, Aaltonen and Marton, 2013; Kim and Kim, 2017; Nambisan, 2017).
- *Direct network effects*: Some digital ventures may provide value to users by facilitating engagement with a network of other users. Examples of such business models are particularly present on social networks, on which users engage with other users such as their friends or colleagues. The larger the number of users that one can engage with, the larger the value provided by the venture (Amit and Zott, 2001; Porter, 2008; Stampfl, Prügl and Osterloh, 2013; Steininger, Wunderlich and Pohl, 2013; Zhang, Lichtenstein and Gander, 2015; Kelestyn, Henfridsson and Nandhakumar, 2017; Täuscher and Abdelkafi, 2018). However, some scholars also argue that negative direct network effects exist for some digital ventures. In such cases, a larger number of the same type of user decreases the value for each user. This may occur, for example, due to more competition within a marketplace (Asvanund *et al.*, 2004; Zhu and Bao, 2018).
- *Indirect network effects*: Indirect network effects refer to improvements in customer value creation because two different types of users interact. This thesis distinguishes these two groups by using the terms users and customers. These network effects are present, for example, on multi-sided markets, in which ventures facilitate transactions between buyers and sellers. However, they are also present on social networks where digital ventures may allow advertising customers to market their products to non-paying users. In such cases, the value of the venture's offer increases with the size of the other type of user on the platform (Amit and Zott, 2001; Pagani, 2013; Staykova and Damsgaard, 2015; Gandia and Parmentier, 2017; Täuscher and Abdelkafi, 2018).
- *Complementary quality*: Other companies may use the openness of digital technologies to provide complementary products to the venture's technology. For example, some social networks allow game developers to provide games

from within the social network. Similarly, many software companies provide interfaces that allow integrating external applications to the venture's software. These complementary products increase the value of the digital venture's product or service depending on their quality (Afuah and Tucci, 2000; Amit and Zott, 2001; Tang, 2006; Song, Parry and Kawakami, 2009; Stampfl, Prügl and Osterloh, 2013; Nambisan, 2017; Eckhardt, Ciuchta and Carpenter, 2018; Teece, 2018).

These five value drivers may affect the strength of the venture's product or service for its users and customers (Figure 4-5). However, digital ventures may make use of these value drivers selectively. For example, SaaS companies may only employ the technological value driver. On the other hand, social networks rely primarily on network effects, while the technology still underpins their product.

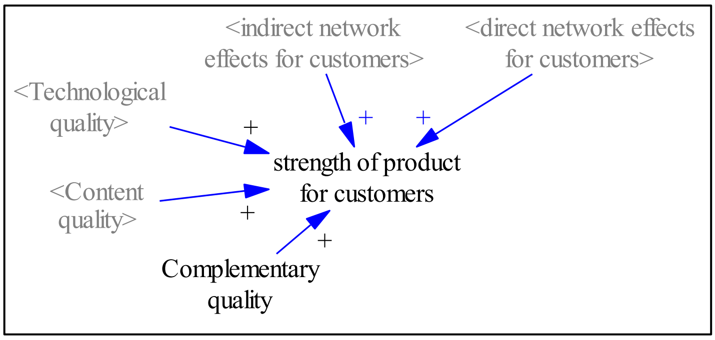


Figure 4-5: Strength of product or service for customers

The model formalises each value driver as an indexed qualitative variable. If a venture relies on the value driver, its initial value is one. Otherwise, the value driver has a value of zero. The model multiplies all value drivers to calculate the product's strength (Equation 4-5). The HasValue function[10] checks each driver's value and returns its value if it is greater than zero. If the value driver has the value of zero, the function returns the value of one. Thereby, unemployed value drivers do not affect the calculation of the product strength.

[10] The HasValue function is a custom macro that has been programmed for the Vensim software as part of this thesis. It ensures that the function still returns an appropriate value for the product quality under extreme input values (their lower bound of zero). It uses an if-structure to determine if the variable is zero. If the variable's value is zero, the function returns its second parameter value. Otherwise, it returns the variable. Please see Appendix B for the equations of the macro.

$$\text{strength of product or service for customers} = \text{HasValue}(\text{Technological quality}, 1) * \text{HasValue}(\text{Content quality}, 1) * \text{HasValue}(\text{Complementary quality}, 1) * \text{HasValue}(\text{direct network effects for customers}, 1) * \text{HasValue}(\text{indirect network effects for customers}, 1) \quad \text{Eq 4-5}$$

The technological quality and network effects for customers are reviewed below. The complementary quality is an exogenous input. Let's suppose complementary products improve the value of the venture's offer. In that case, the quality of complementary products is initially set as one. The analyst then sets it every year to reflect the average complementary product's percentage improvement. For example, a value of 1.1 at a later point in time would indicate that the average quality of complementary products has improved by 10%. Appendix A provides further details on the product strength for users, network effects for users, and content quality.

4.1.3.1. Technological quality

The technological quality reflects the quality of the firm's software offering. It is formalised as a qualitative variable with the *initial technological quality* set as one. The venture transforms financial resources on its balance sheet into technological resources when it invests in technology. This indicates that the venture improved its product technologically (Huang and Kunc, 2012). The same technology s-curve conceptualised in the previous chapter exists for a digital venture's technology. Thus, the initial investments into technologies only yield minor quality improvements. With further investments, the rate of quality improvements per investment accelerates before it starts to decline as the s-curve reaches its maximum value (Sosa, Browning and Mihm, 2007; Nikula *et al.*, 2010). The structure and equation illustrated in Sterman's (2000) System Dynamics manual have been used to model this s-curve relationship (Figure 4-6).

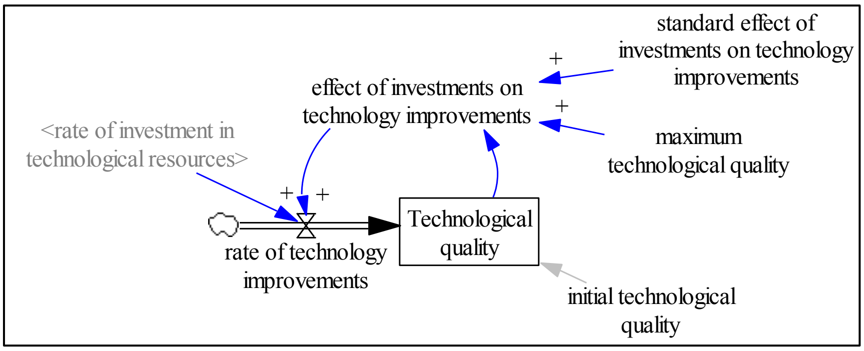


Figure 4-6: Technological quality

In Sterman's (2000) structure, the *technological quality* accumulates based on the *rate of technology improvements* (Equation 4-6). These improvements depend on the *rate of investment in technological resources* and the *effect of investments on technology improvements* (Equation 4-7).

$$\text{Technological quality} \qquad \text{Eq 4-6}$$
$$= \text{initial technological quality} + \int \text{rate of technology improvements}$$

$$\text{rate of technology improvements} \qquad \text{Eq 4-7}$$
$$= \text{rate of investment in technological resources} * \text{effect of investments on technology improvements}$$

The model calculates the effect of investments in technology on technological improvements based on the *technological quality* already achieved, the *maximum technological quality*, and the *standard effect of investments on technology improvements* (Equation 4-8). These elements are combined using the equation provided by Sterman (2000), which adjusts the standard effect by two factors. Initially, the effect size increases with a greater stock of technological quality. However, as the quality reaches the maximum, the second factor affecting the standard effect becomes smaller until no further improvements can be realised.

$$\text{effect of investments on technology improvements} \qquad \text{Eq 4-8}$$
$$= \text{standard effect of investments on technology improvements} * \text{Technological quality} * (\text{maximum technological quality} - \text{Technological quality})/\text{maximum technological quality}$$

The analyst needs to set the maximum technological quality after reviewing the types of improvements that the firm makes over the period of investigation. The standard effect has been calibrated automatically using the Vensim software.

4.1.3.2. Network effects for customers

Users and customers may both benefit from direct and indirect network effects. Therefore, four different network effects are considered in the model. The two relevant for customers are presented below: the *direct network effects for customers* and *indirect network effects for customers* (Figure 4-7). As argued above, different business models may employ different types of network effects (Stampfl, Prügl and Osterloh, 2013; Staykova and Damsgaard, 2015; Gandia and Parmentier, 2017; Täuscher and Abdelkafi, 2018; Zhu and Bao, 2018).

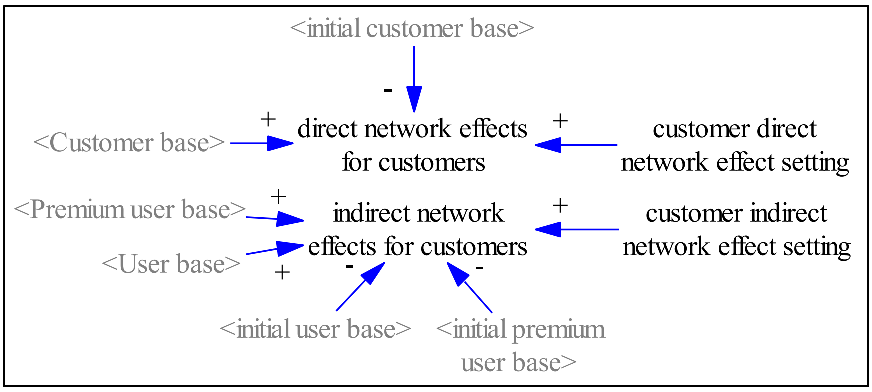


Figure 4-7: Network effects for customers

Each network effect has an initial value of one if the venture employs it and zero if the venture does not. This ensures the indexing of value creation. Sterman (2000) suggests normalising such quality factors. Therefore, each network effect is expressed by comparing the current *user base* and *customer base* to a reference point. These reference points are, respectively, the *initial user base*, *initial premium user base*, and *initial customer base* (Equation 4-9, 4-10).

$$\text{direct network effects for customers} \\ = \text{IF THEN ELSE(customer direct network effect setting} \\ = 0, 0, \text{(Customer base} \\ \text{/initial customer base)\^{}customer direct network effect setting)} \qquad \text{Eq 4-9}$$

$$\begin{aligned}
&\text{indirect network effects for customers} \qquad \text{Eq 4-10}\\
&= \text{IF THEN ELSE(customer indirect network effect setting}\\
&= 0, 0, ((\text{Premium user base} + \text{User base})/(\text{initial user base}\\
&+ \text{initial premium user base}))\text{\^{}customer indirect network effect setting)}
\end{aligned}$$

The model accounts for different business model designs through the *network effect setting* variables. If a venture does not employ a network effect, the analyst needs to set the respective variable as zero. The if-structure in the above equation then sets the network effect to zero (setting=0). For positive and negative network effects, the variable needs to be set as one and minus one. The power function then ensures that a greater user base increases network effects proportionally for positive network effect (setting=1). It also creates a reduction in network effects proportional to increases in the customer and user base for negative effects (setting=-1). Thereby, as suggested by Coyle (1996), these variables operate as policy switches. They adjust the feedback structure of network effects depending on the business model employed by a case company.

4.1.4. Customer usage intensity

As argued above, digital products create value for customers over time. However, the use value created per customer also changes with the intensity at which the average customer uses a product (Kim, Oh and Shin, 2010). For example, customers learn to use a software's interface and features over time (Amit and Zott, 2001; Deng and Wang, 2016). Users and customers may also personalise or customise digital technologies by adopting profiles on social networks or customising software for business processes (DaSilva *et al.*, 2013; Tucker, 2018). Existing customers will improve the value they generate from using a digital product towards a maximum. This maximum may reflect, for example, the number of features or content items available to the user. However, new customers lower the average value created for each customer because they have yet to go through the same learning, customisation, and adoption processes (Figure 4-8).

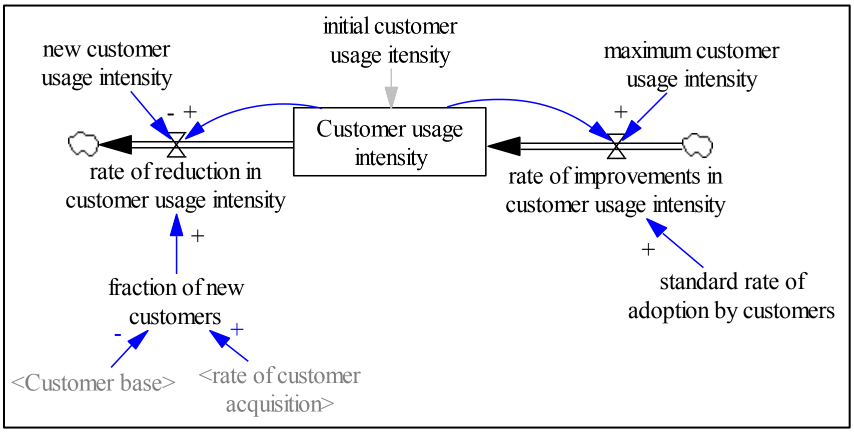


Figure 4-8: Customer usage intensity

The model combines two established structures to represent the processes of increasing usage intensity and adjustments to new customers (Equation 4-11). Firstly, it utilises Sterman's (2000) s-curve to model the process of increasing usage intensity towards a the *maximum customer usage intensity*. This is reflected in the *rate of improvements in customer usage intensity* (Equation 4-12). Secondly, it uses Warren's (2002) structure to adjust the quality of resources such as customer bases. This adjustment through the *rate of reduction in customer usage intensity* depends on the *new customer usage intensity* and the *fraction of new customers* (Equation 4-13, 4-14)[11].

$$\text{Customer usage intensity} \qquad \text{Eq 4-11}$$

$$= \text{initial customer usage itensity} + \int (\text{rate of improvements in customer usage intensity} - \text{rate of reduction in customer usage intensity})$$

$$\text{rate of improvements in customer usage intensity} \qquad \text{Eq 4-12}$$

$$= \text{standard rate of adoption by customers} * \text{Customer usage intensity} * \text{ZIDZ(maximum customer usage intensity} - \text{Customer usage intensity, maximum customer usage intensity)}$$

[11] The XIDZ and ZIDZ functions prevent divisions by zero. The ZIDZ function requires a dividend and a divisor separated by a comma. The XIDZ function requires a return value as a third argument. If the divisor is zero, the XIDZ functions return the third argument, while the ZIDZ function returns zero. They ensure that the equations work under extreme conditions.

$$\text{rate of reduction in customer usage intensity} = (\text{Customer usage intensity} - \text{new customer usage intensity}) * \text{fraction of new customers} \quad \text{Eq 4-13}$$

$$\text{fraction of new customers} = \text{XIDZ}(\text{rate of customer acquisition}, \text{Customer base}, 1) \quad \text{Eq 4-14}$$

The *initial customer usage intensity* has a value of one to index value creation. The maximum usage intensity, the speed of adoption, and the usage intensity of new customers are constant throughout a growth state. The analyst needs to set them based on the case company's data. Analysts can use different data points to approximate them. These may include, for example, time spent using software, the rate of content consumption, the rate of engagement in a network or transactions, the number of complementary products used by the average, or the number of employees in a company using a product (Bontis and Chung, 2000; Amit and Zott, 2001; Haile and Altmann, 2016b; Lyytinen, Yoo and Boland, 2016; Nambisan, 2017; Guggenberger *et al.*, 2020).

4.1.5. Calculation of reported figures and accounting performance

Practitioners and empirical studies commonly use a company's financial statements to evaluate its performance. They may use revenues to approximate value creation in the corresponding periods. Revenue growth between two consecutive periods is then used to approximate the growth in value creation (Porter, 1985; Garnsey, Dee and Ford, 2006; Steffens, Davidsson and Fitzsimmons, 2009). The model allows comparing the theory-driven conceptualisation of value creation to accounting measures such as revenue, which are widely available due to financial reporting requirements. However, there are conceptual differences between the values on financial statements and the variables in System Dynamics models. Reported figures need to be derived before calculating accounting performance measures to overcome these differences.

There is a significant conceptual difference between the rate variables specified above and the accounting figures shown on the firm's financial statements. Both measure a venture's performance over a period of time (Warren, 1999, 2002). However, accounting measures illustrate absolute amounts over a period. For example, revenue as the top line of an income statement reflects the amount of money captured from customers over the last financial year. On the other hand, the variables in a System Dynamics model express instantaneous rates of change (Sterman, 2000). After simulating a System Dynamics model for one year, the revenue variable in the model does not show how much value a company has generated over the past year. The variable shows the annualised rate of revenue generation at that point in time. Thus, the accounting measures are backwards-looking, i.e. report the revenue generated over the last twelve months. The instantaneous rates of change expressed by System Dynamics variables have the advantage of measuring performance in the moment. This allows managers to assess the performance of their firm timelier. However, System Dynamics modellers also need to model the reporting system (Sterman, 2005). Because "level variables are the only directly observable variables in a system; instantaneous rates of flow are not observable", modellers need to average accounting figures over the reporting period. This *reporting period* is set as one year to correspond to annual reports. One can then use these averages to calibrate and test the model by comparing these values to financial statements (Forrester, 1984, p. 8; Sterman, 2000, 2015; Oliva, Sterman and Giese, 2003). This relationship has been used to derive the *rolling annual revenue* (Figure 4-9).

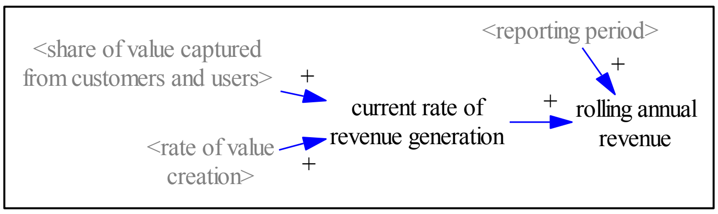


Figure 4-9: Rolling annual revenue

The rolling annual revenue is the average of the *current rate of revenue generation* over the last year. Following Oliva, Sterman, and Giese (2003), a custom macro has been programmed for the Vensim software to derive these averages. It uses a stock with the current rate as an inflow and the rates no longer part of the reporting period as outflows (Equation 4-15) [12].

$$\text{rolling annual revenue} = \text{ReportedFinancials}\,(\text{current rate of revenue generation}, \text{reporting period}) \qquad \text{Eq 4-15}$$

The share of value captured from customers and users reflects the fraction of the created value that is captured as revenue. Multiplying it with the *rate of value creation* yields the *current rate of revenue generation* (Equation 4-16).

$$\text{current rate of revenue generation} = \text{rate of value creation} * \text{share of value captured from customer and users} \qquad \text{Eq 4-16}$$

This share of value captured from customers and users is an input from the value capture subsystem presented in the next section. This equation and the use of a variable related to capturing value illustrate the limitations of revenue as a proxy of value creation used in previous empirical studies. Due to competition, the price paid by customers for a product is usually lower than their maximum willingness to pay. Therefore, the amount of value creation is usually greater than revenue. Moreover, a fall in revenue does not necessarily imply that the venture creates less value. Revenue may have dropped due to increasing competition (Lepak, Smith and Taylor, 2007). The model uses the strength of simulation models, which are not constrained by exact numerical measurement of concepts (Langley, 1999). This allows it to separate the rate of value creation and the rate of revenue generation. The model reflects value creation as theories conceptualise it without the use of revenue as a proxy.

[12] The macro includes a stock that averages the accounting figures over the reporting period. When less than a full period has passed in the model, and there is not a full year of data in the stock, the macro annualises the current content of the stock. Appendix B illustrates the full details of this macro.

4.1.6. Overview of subsystem inputs

This section has contextualised and formalised value creation as the first performance outcome for digital ventures during the growth process. The outcomes of the subsystem are the rate of value creation as the theoretical performance measure and revenue as a proxy (Table 4-1). This proxy can be compared to financial statements to test the model. The model derives these outcomes by accounting for different customer and user groups, value creation over time, diverse value drivers, and changing usage intensities. Through these mechanisms, variables related to a venture's resources have been identified as affecting value creation. The share of value captured is also required to calculate revenue. These inputs are discussed in the other sections of this chapter that cover the respective subsystems of the formal model.

Table 4-1: Outputs and inputs of the value creation subsystem

Outputs	
• Rate of value creation as the theoretical performance measure • Rolling annual revenue as an accounting proxy for value creation	
Inputs from other subsystems	**Exogenous inputs**
Customer and user subsystem: • Customer base, user base, premium user base • Rate of customer acquisition, rate of user acquisition, rate of premium user acquisition • Initial customer base, initial user base, initial premium user base **Technology development subsystem:** • Rate of investment in technological resources **Content creation subsystem:** • Content library, rate of content creation • Quality of new content items **Value capture subsystem:** • Share of value captured from customers and users	**Business model design:** • Premium product advantage • Maximum technological quality, standard effect of investment in technology on technological improvement • Customer direct network effect settings, customer indirect network effect settings, user direct network effect settings, user indirect network effect settings • Initial content quality **Environment – Customer and user behaviour:** • Initial customer usage intensity, initial user usage intensity • New customer usage intensity, new user usage intensity • Maximum customer usage intensity, maximum user usage intensity • Standard rate of adoption by customers, standard rate of adoption by users **Environment – Complementary products:** • Complementary quality

In addition to the variables calculated in other subsystems, the value creation subsystem relies on inputs set by the analyst based on information in the company's annual reports. Some of these variables are required to set up the model for a venture's business model. These variables activate or deactivate specific mechanisms in the model to represent, for example, freemium business models or network effects. The analyst also needs to set the maximum technological quality by reviewing the nature of changes executed on the venture's technology. The standard effect of investments into technology on the technological quality is set using automatic model calibration. Lastly, other variables reflect environmental conditions such as customer and user behaviour and complementary product quality.

4.2. Value capture subsystem

This section traces the influences on a digital venture's share of value captured back to variables in other subsystems (Figure 4-10). The share of value captured from customers and users depends on influences from the value creation subsystem, the business model design, and competition in the external environment. The shares of value lost to input providers and the erosion of resources depend on influences from the business model subsystems and the input providers in the external environment. Like the value creation subsystem, the model formalises the share of value captured based on theory. In addition, it derives profitability ratios using the share of value captured, which can be compared to case companies' financial statements.

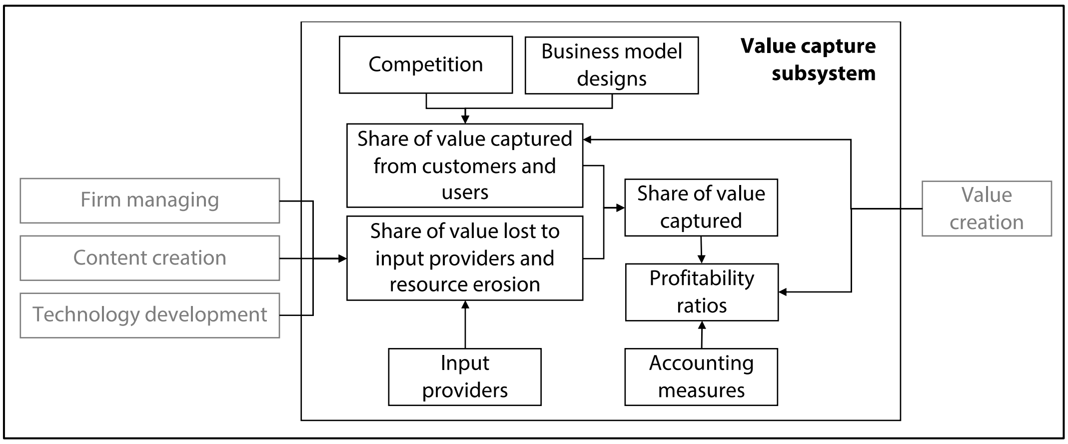


Figure 4-10: Value capture subsystem

The share of value captured reflects the fraction of created value received and maintained by the venture as profit (Teece, 1986; Zott and Amit, 2010). As conceptualised in growth process theories, it depends on the share of value captured from customers and users and the share of value lost to input providers and the erosion of resources (Figure 4-11).

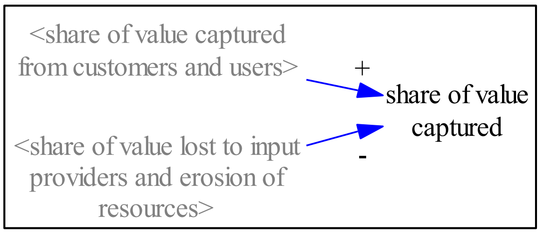


Figure 4-11: Share of value captured

The formal model subtracts the *share of value lost to input providers and erosion of resources* from the *share of value captured from customers and users* (Equation 4-17). The share of value captured from customers and users represents the fraction of created value captured as revenue. The share of value lost to input providers expresses the venture's costs as a fraction of the value creation. The calculated difference thus expresses the *share of value captured* as the fraction of value maintained by the venture.

$$\begin{aligned} &\text{share of value captured} \\ &= \text{share of value captured from customers and users} \\ &- \text{share of value lost to input providers and erosion of resources} \end{aligned} \qquad \text{Eq 4-17}$$

Below, the share of value captured from customers and different shares of value lost have been adapted for the digital context. The model further formalises them to identify the input variables in the venture's resource base and environment.

4.2.1. Share of value captured from customers

While physical-product companies usually capture value from all customers, digital ventures may capture value more selectively from their customer and user bases. Firstly, despite creating value for different types of users and customers, digital ventures may not capture value from all types. For example, many digital marketplaces connecting buyers and sellers capture value only from sellers by charging a transaction fee, whereas the service is free for buyers. Similarly, social networks do not usually capture value from their users but capture value from their advertising customers (Afuah and Tucci, 2000; Muzellec, Ronteau and Lambkin, 2015; Staykova and Damsgaard, 2015; Remane *et al.*, 2016; Gandia and Parmentier, 2017). Secondly, digital ventures employing a freemium business model may capture value only from premium users but not from ordinary users. SaaS companies and some social networks and content providers may employ freemium models to allow users to test the product and entice them to purchase the upgraded version (Teece, 2010; Roma and Dominici, 2016; Voigt and Hinz, 2016; Möller *et al.*, 2020).

The model distinguishes different types of users and customers for value creation. Similarly, it distinguishes the types for value capture. The share of value captured from customers and users considers that value is only captured from customers and premium users, while no value is captured from standard users. In growth process theories, the share of value captured depends on the bargaining power of the venture to its customers (Porter, 1991; Peteraf and Barney, 2003; Garnsey, Dee and Ford, 2006; Lepak, Smith and Taylor, 2007). This logic has been applied to the value captured from customers and premium users (Figure 4-12).

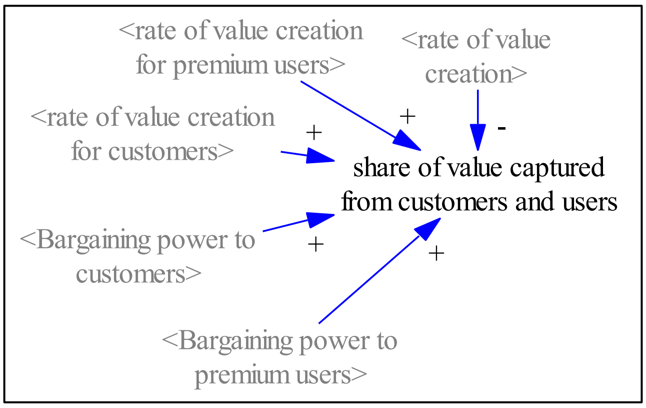


Figure 4-12: Share of value captured from customers and users

The *bargaining power to customers* and *bargaining power to premium users* reflects the fraction of value captured from customers and premium users. The model calculates the average of these two bargaining powers, weighted by their share of value creation (Equation 4-18).

$$
\begin{aligned}
\text{share of value captured from customers and users} & \\
&= \text{Bargaining power to customers} \\
&* (\text{rate of value creation for customers} \\
&/\text{rate of value creation}) \\
&+ \text{Bargaining power to premium users} \\
&* (\text{rate of value creation for premium users} \\
&/\text{rate of value creation})
\end{aligned}
\qquad \text{Eq 4-18}
$$

The value creation subsystem models the rates of value creation. The bargaining power and its influences are discussed below[13].

4.2.1.1. Bargaining power to users and customers

The bargaining power to customers reflects the fraction of value captured from the average customer. As in the conceptual model, this bargaining power depends on the strength of the venture's product or service relative to the strength of competitor and substitute products (Porter, 1991; Peteraf and Barney, 2003; Garnsey, Dee and Ford, 2006; Lepak, Smith and Taylor, 2007). While this general principle is maintained, the formal model adjusts the mechanisms for two particularly prominent specifications in the digital context (Figure 4-13). Firstly, existing customers develop switching costs over time. These costs make existing customers less likely to switch to competitors or substitutes and thus increase the venture's bargaining power to customers. Moreover, the development of switching costs implies that ventures have a lower bargaining power to new customers. These new customers have not yet developed switching costs (Amit and Zott, 2001; Marquez and Blanchar, 2006; Kooskora, 2020). Secondly, some digital ventures lock customers into contracts for months, years, and some even longer than three years. Such contract periods are particularly prominent among SaaS ventures in a business-to-business context. This contract period delays the impact of competition, product improvements, and switching costs on the bargaining power (Harmon, Raffo and Faulk, 2004; Saaksjarvi and Lassila, 2005; Tyrväinen and Selin, 2011; Voigt and Hinz, 2016; Kohtamäki *et al.*, 2019).

[13] Just as for the value creation mechanisms, this subsection focuses on customers. The same mechanisms also exist for the value captured from premium users. To avoid repetition, these are presented in Appendix A.

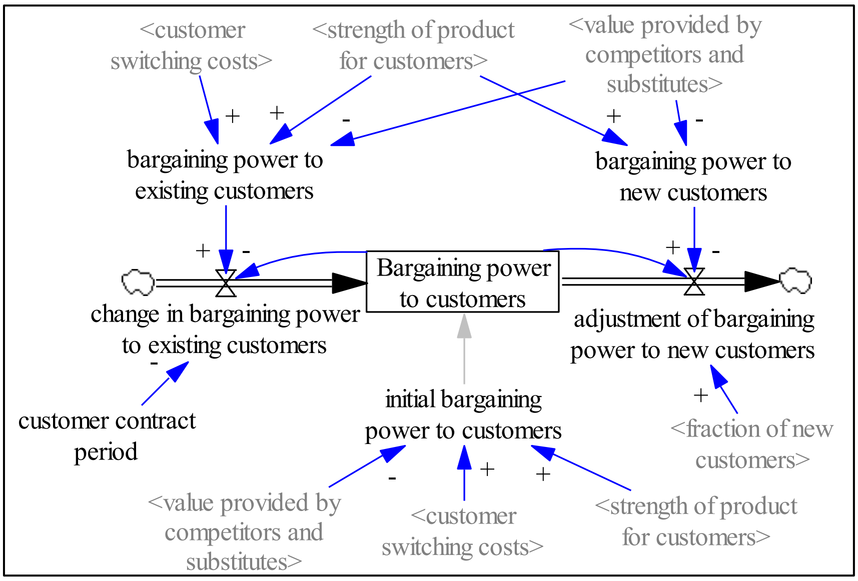


Figure 4-13: Bargaining power to customers

The structure used to model the usage intensity has been adjusted to formalise the development of the bargaining power to customers. Over time, the *initial bargaining power to customers* changes through improvements in the bargaining power to existing customers and adjustments for the bargaining power to new customers (Equation 4-19). The *change in bargaining to existing customers* adjusts the overall bargaining power to the *bargaining power to existing customers* over the *customer contract period* (Equation 4-20). The *adjustment of bargaining power to new customers* reduced the bargaining power towards the *bargaining power to new customers* depending on the *fraction of new customers* (Equation 4-21).

Bargaining power to customers Eq 4-19

$$\begin{aligned}&= \text{initial bargaining power to customer}\\&+ \int (\text{change in bargaining power to existing customers}\\&- \text{adjustment of bargaining power to new customers})\end{aligned}$$

change in bargaining power to existing customers Eq 4-20

$$\begin{aligned}&= \text{ZIDZ(bargaining power to existing customers}\\&- \text{Bargaining power to customers, customer contract period)}\end{aligned}$$

$$\text{adjustment of bargaining power to new customers} = (\text{Bargaining power to customers} - \text{bargaining power to new customers}) * \text{fraction of new customers} \qquad \text{Eq 4-21}$$

The *bargaining power to new customers* depends on the *strength of the product for customers* relative to the *value provided by competitors and substitutes* (Equation 4-22). These two variables have been combined through an equation commonly used when considering competition, for example, to determine market shares (Sterman, 2000). The model uses this equation because it fulfils the theoretical underpinning of the bargaining power in growth process theories. When there is no competition, the venture's bargaining power is one, and it captures the entire value created. With increasing competition, the bargaining power reduces but never turns negative. The equation fulfils these conditions for extreme values and ensures the bargaining power always remains between zero and one. The model also considers *customer switching costs* to calculate the *initial bargaining power* and *bargaining power to existing customers*. The model uses switching costs as a multiplier that increases the strength of the product for customers. If there are no switching costs, the product strength of existing customers stays at the level for new customers (Equation 4-23, 4-24).

$$\text{bargaining power to new customers} = \text{ZIDZ}(\text{strength of product for customers}, \text{strength of product for customers} + \text{value provided by competitors and substitutes}) \qquad \text{Eq 4-22}$$

$$\text{initial bargaining power to customer} = \text{ZIDZ}(\text{strength of product for customers} * (1 + \text{customer switching costs}), \text{strength of product for customers} * (1 + \text{customer switching costs}) + \text{value provided by competitors and substitutes}) \qquad \text{Eq 4-23}$$

$$\text{bargaining power to existing customers} \qquad \text{Eq 4-24}$$
$$= \text{ZIDZ}(\text{strength of product for customers} * (1 + \text{customer switching costs}), \text{strength of product for customers} * (1 + \text{customer switching costs}) + \text{value provided by competitors and substitutes})$$

The value creation subsystem has reviewed the product strength. The switching costs and value provided by competitors and substitutes are described below. The contract period is set based on statements made in the company's annual reports and on its website.

4.2.1.2. Customer switching costs

The development of customer switching costs increases the bargaining power of the venture to its customers over time. These switching costs develop as customers increase their usage intensity. For example, Amit and Zott (2001) argue that the familiarity gained from learning to use a user interface or feature is a form of switching costs. DaSilva *et al.* (2013) describe customising settings and inserting data to cloud platforms as switching costs. Similarly, Tucker (2018) describes the effort made to customise user profiles on social networks as switching costs. The model has considered these processes of personalising, customising, and learning about a digital product or service via the usage intensity (Subsection 4.1.4). In the mechanism, new customer usage intensity increases towards a maximum over time. The model expresses switching costs as the increase in the usage intensity (Figure 4-14). The model also formalises a process to approximate the average usage intensity by new customers to account for companies changing their target customers to ones with different usage intensities.

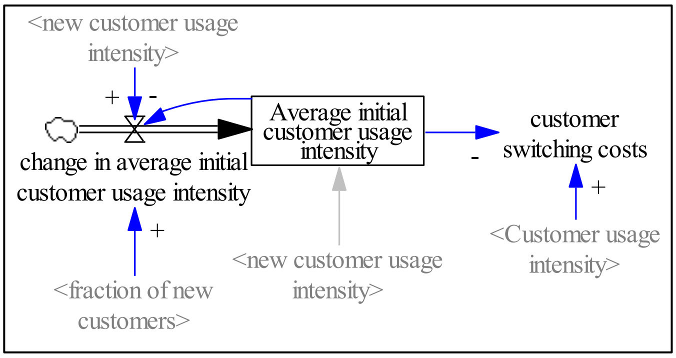


Figure 4-14: Customer switching costs

The model calculates customer switching costs as the increase in the *customer usage intensity* expressed as a fraction of the *average initial customer usage intensity* (Equation 4-25). The average rate's initial value is the usage intensity of new customers at the beginning of the simulation. It is then adjusted to reflect changes in the venture's target customers (Equation 4-26). The *change in average initial customer usage intensity* moves the current average towards the *new customer usage intensity* depending on the *fraction of new customers* (Equation 4-27). If the venture does not change its target customer segment, no adjustment takes place. Similarly, no adjustment takes place when no new customers are acquired.

customer switching costs Eq 4-25

$$= \text{ZIDZ(Customer usage intensity} \\ - \text{Average initial customer usage,} \\ \text{Average initial customers usage intensity)}$$

Average initial customers usage intensity Eq 4-26

$$= \text{new customer usage intensity} \\ + \int \text{(change in average initial customer usage intensity)}$$

change in average initial customer usage intensity Eq 4-27

$$= \text{(new customer usage intensity} \\ - \text{Average initial customer usage intensity)} \\ * \text{fraction of new customers}$$

All inputs to this part of the model are derived in the value creation subsystem.

4.2.1.3. Value provided by competitors and substitutes

The number of competitors and substitute providers and the strength of their products affect the *value provided by competitors and substitutes* (Figure 4-15). The number of competitors can be expressed by the market conditions as monopolies, oligopolies, and perfect competition. Competitors' and substitutes' strength refers to the quality of the average competitor product or substitute (Porter, 1991; Peteraf and Barney, 2003; Lepak, Smith and Taylor, 2007; Zhu and Iansiti, 2007; Naudé and Liebregts, 2009; Ma and Kauffman, 2014; Ruutu, Casey and Kotovirta, 2017; Teece, 2018).

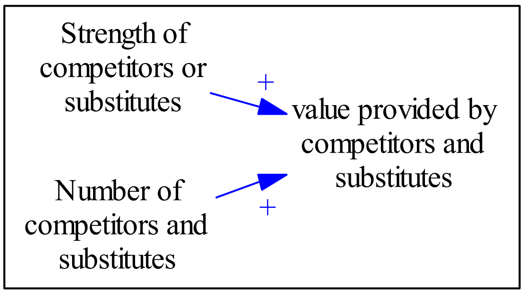


Figure 4-15: Value provided by competitors and substitutes

The model multiplies together the *strength of competitors or substitutes* and the *number of competitors or substitutes* to calculate the value provided by competitors and substitutes (Equation 4-28).

$$\begin{aligned}\text{value provided by competitors and substitutes} \\ = \text{Strength of competitors or substitutes} \\ * \text{Number of competitors and substitutes}\end{aligned} \qquad \text{Eq 4-28}$$

Similar to the use value created by the digital venture for its users and customers, both variables are treated as qualitative variables. The analyst needs to set the number of competitors and substitutes based on whether the market is a monopoly (0), an oligopoly (0.25), or under perfect competition (1). The analyst sets the strength of competitors and substitutes to represent their relative product strength based on the qualitative information provided in annual reports. For example, the average competitors' product might be equally good (1) or only have 80% of the functionality of the venture's product (0.8).

4.2.2. Share of value lost to input providers and erosion of resources

The venture loses value due to the erosion of its resources and the compensation paid to input providers. The overall logic for non-digital businesses conceptualised in growth process theories can also be applied to digital ventures. Below, these shares of value lost are formalised. Thereby, this subsystem adds further details explaining the influences of resources and the external environment on the shares of value lost (Figure 4-16).

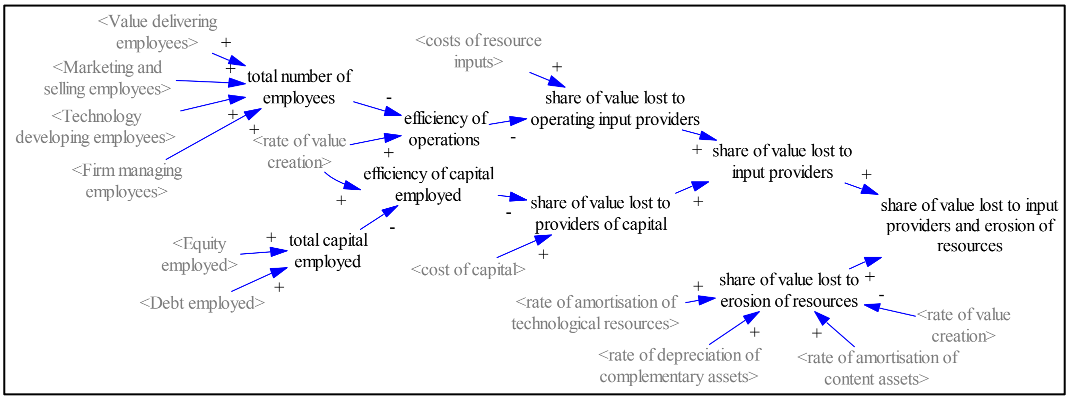


Figure 4-16: Share of value lost to input providers and resource erosion

The *share of value lost to input providers and the erosion of resources* is the fraction of created value lost during the value creation process. It is composed of two fractions that are added up (Equation 4-29).

$$\text{share of value lost to input providers and erosion of resources} \quad \text{Eq 4-29}$$
$$= \text{share of value lost to input providers}$$
$$+ \text{share of value lost to erosion of resources}$$

The *share of value lost to input providers* expresses the costs to compensate input providers as a fraction of the value created. The share of value lost to input providers is a fraction equal to or larger than zero. It aggregates the share of value lost to each type of input provider identified in the model's conceptualisation. These are operating input providers in the form of human resources and providers of capital. Thus, it adds up the *share of value lost to operating input providers* and the *share of value lost to providers of capital* (Equation 4-30). The share of value lost to operating input providers is calculated based on the *efficiency of operations* and the *cost of resource inputs* (Equation 4-31), while the share of value lost to providers of capital is calculated based on the *efficiency of capital employed* and the *cost of capital* (Equation 4-32). Each statement of efficiency reflects how much value is created per unit of resource input. Therefore, the inverse of each efficiency statement determines how many units of a resource are required to create one unit of value. Multiplying the cost per unit of resource with the inverse of the efficiency thus determines the share of value lost to each input provider. The model uses the venture's *total number of employees* as its operating resource use (Equation 4-33) and the *capital employed* as its capital resource use (Equation 4-34). The model considers four different types of human resources that make up the venture's total number of employees: *value delivering employees*, *marketing and selling employees*, *technology developing employees*, and *firm managing employees* (Equation 4-35). Similarly, the model considers the *equity employed* and the *debt employed* (Equation 4-36). These resources are inputs from the firm managing subsystem. The costs per unit of resource are reviewed below.

$$\begin{aligned}\text{share of value lost to input providers}\\ &= \text{share of value lost to operating input providers}\\ &+ \text{share of value lost to providers of capital}\end{aligned} \qquad \text{Eq 4-30}$$

$$\begin{aligned}\text{share of value lost to operating input providers}\\ &= \frac{1}{\text{efficiency of operations}} * \text{cost of resource inputs}\end{aligned} \qquad \text{Eq 4-31}$$

$$\begin{aligned}\text{share of value lost to providers of capital}\\ &= \frac{1}{\text{efficiency of capital employed}} * \text{cost of capital}\end{aligned} \qquad \text{Eq 4-32}$$

$$\text{efficiency of operations} = \frac{\text{rate of value creation}}{\text{total number of employees}} \qquad \text{Eq 4-33}$$

$$\text{efficiency of capital employed} = \frac{\text{rate of value creation}}{\text{total capital employed}} \qquad \text{Eq 4-34}$$

$$\begin{aligned}\text{total number of employees}\\ &= \text{Firm managing employees}\\ &+ \text{Marketing and selling employees}\\ &+ \text{Technology developing employees}\\ &+ \text{Value delivering employees}\end{aligned} \qquad \text{Eq 4-35}$$

$$\text{total capital employed} = \text{equity employed} + \text{debt employed} \quad \text{Eq 4-36}$$

The second source of value slippage is the erosion of the venture's resources in its value creation process (Nelson and Winter, 1978; Dierickx and Cool, 1989; Porter, 1991; Knott, Bryce and Posen, 2003). The *share of value lost to the erosion of resources* expresses the sum of all amortisation and depreciation expenses as a fraction of the value created (Equation 4-37).

$$\begin{aligned}\text{share of value lost to erosion of resources} \quad & \quad \text{Eq 4-37} \\ = (&\text{rate of amortisation of technological resources} \\ &+ \text{rate of depreciation of complementary assets} \\ &+ \text{rate of amortisation of content assets}) \\ &/\text{rate of value creation}\end{aligned}$$

The rates of amortisation and depreciation are formalised in the technology development, content creation, and firm managing subsystems.

4.2.2.1. Operating of resource inputs

The cost of resource inputs reflects the annual costs per employee. Four different types of human resources and activities have been specified above. Each type of employee is associated with different costs, determined by labour market conditions (Garnsey, 1998). For example, programmers as part of the firm's technology developing employees are in high demand. Therefore, they can command a higher wage than, for example, marketing and sales employees. In addition to wages, the expenses per employee in the model also include other costs paid to suppliers that are part of employee activities. The model calculates the *cost of resource inputs* as the weighted average of the different human resource costs (Figure 4-17).

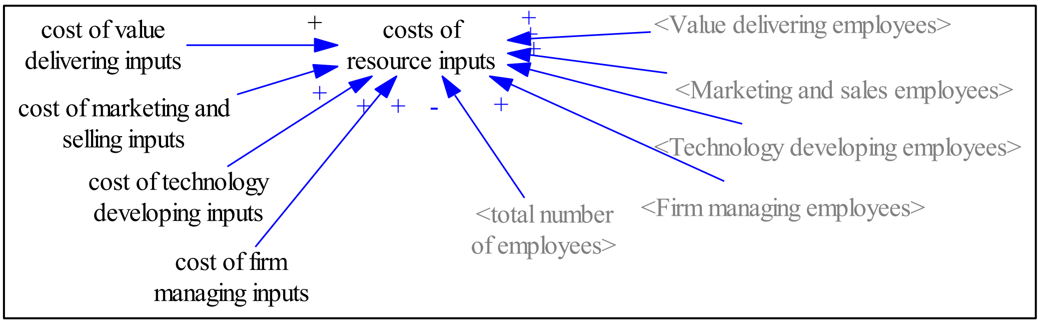


Figure 4-17: Cost of resource inputs

The model calculates the *cost of resource inputs* as a weighted average. It multiplies the number of employees by their respective costs and then divides the sum of those products by the total number of employees (Equation 4-38).

$$\begin{aligned}\text{cost of resource inputs} \\ &= (\text{Value delivering employees} \\ &* \text{cost of value delivering inputs} \\ &+ \text{Marketing and selling employees} \\ &* \text{cost of marketing and selling inputs} \\ &+ \text{Technology developing employees} \\ &* \text{cost of technology developing inputs} \\ &+ \text{Firm managing employees} \\ &* \text{cost of firm managing inputs}) \\ &/\text{total number of employees}\end{aligned} \qquad \text{Eq 4-38}$$

Each input cost is exogenous to the model. They are calculated by dividing the firm's annual indexed expenses on the income statement by the firm's average number of indexed employees during the year. If the firm changes its growth state, the cost per input might change. For example, companies may internalise more activities, thereby hiring more employees while also altering the cost of that activity (Levie and Lichtenstein, 2010). The averages of values within growth states with the same input constellation have been used as model inputs.

4.2.2.2. Providers of capital

The *cost of capital* reflects the annual costs of each unit of capital employed. These costs are paid to the venture's providers of capital. While the *cost of equity* relates to the return provided to equity investors through dividends, the *cost of debt* reflects the interest rate provided to debt investors. The higher each cost of capital, the higher the overall cost of capital (Figure 4-18).

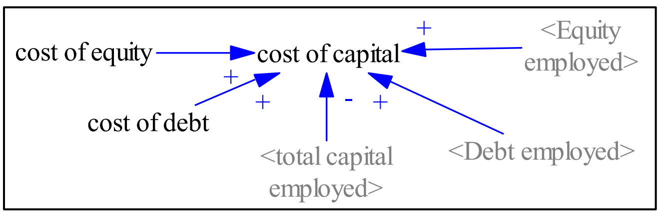


Figure 4-18: Cost of capital

The cost of capital is calculated as the weighted average of the cost of equity and the cost of debt (Equation 4-39).

$$\text{cost of capital} = (\text{Equity employed} * \text{cost of equity} + \text{Debt employed} * \text{cost of debt})/\text{total capital employed} \qquad \text{Eq 4-39}$$

The cost of equity and debt are exogenous inputs to the model. They are calculated as inputs from the firm's financial statements by dividing the respective cost, i.e. the interest expense or dividends, by the average amount of debt or equity employed in the expense's year. They are primarily driven by capital market conditions (Garnsey, 1998), which the firm is too small to affect significantly. They are held constant over a growth state (Levie and Lichtenstein, 2010).

4.2.3. Calculation of reported figures and accounting measures

Empirical studies, managers, and investors may approximate the firm's ability to capture value using its return on assets. Thereby, the efficiency of using the resources recognised on the venture's balance sheet to generate net income is expressed (Ireland, Hitt and Sirmon, 2003; Davidsson, Steffens and Fitzsimmons, 2009; Delmar, McKelvie and Wennberg, 2013; Zhou, Park and Ungson, 2013). While most studies measure the ability to capture value with return on assets, growth paths theory has suggested profit margins as an alternative proxy (Garnsey, Dee and Ford, 2006). Similar to the value creation subsystem, the model allows comparing the theory-driven conceptualisation of value capture to accounting performance measures. This requires the conversion of model rates to annualised, reported figures.

4.2.3.1. Calculation of reported figures

As for revenue in the value creation subsystem, the instantaneous rates of change of the model need to be converted to annualised figures (Forrester, 1984; Warren, 1999, 2002; Sterman, 2000, 2005, 2015; Oliva, Sterman and Giese, 2003). The same logic applied to revenue has been applied to determine the *rolling annual operating expenses* and *rolling annual financing expenses* (Figure 4-19).

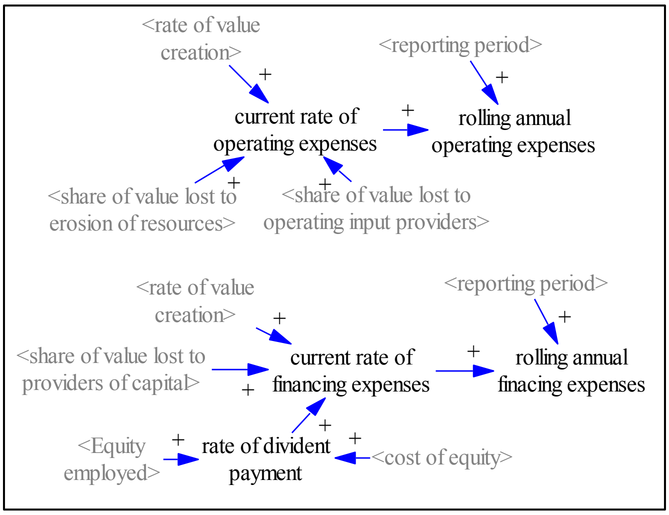


Figure 4-19: Rolling annual expenses

The rolling annual operating expenses and rolling annual financing expenses are the averages of the *current rate of operating expenses* and *the current rate of financing expenses* over the reporting period of one year. The model uses the macro utilised in the value creation subsystem to derive these averages (Equation 4-40, 4-41).

$$\text{rolling annual operating expenses} = \text{Reported Financials}(\text{current rate of operating expenses}, \text{reporting period}) \tag{Eq 4-40}$$

$$\text{rolling annual financing expenses} = \text{ReportedFinancials}(\text{current rate of financing expenses}, \text{reporting period}) \tag{Eq 4-41}$$

The *current rate of operating expenses* includes compensations made to input providers and depreciation and amortisation expenses. In the model, the *share of value lost to operating input providers* and the *share of value lost to erosion of resources* represents these costs as fractions of the created value. The current rate at which operating expenses are incurred can be obtained by multiplying the sum of the fractions with the rate of value creation (Equation 4-42).

$$\text{current rate of operating expenses} = \text{rate of value creation} * (\text{share of value lost to operating input providers} + \text{share of value lost to erosion of resources}) \tag{Eq 4-42}$$

The *current rate of financing expenses* expresses the rate at which the venture incurs financing expenses to compensate capital providers. The *share of value lost to providers of capital* expresses these expenses as a fraction of the value created. Multiplying this fraction with the rate of value creation determines the rate of financing expenses. However, there is a conceptual difference regarding financing expenses between the financial statements and growth process theories. Accountants consider dividends irrelevant to profit. Growth process theories consider dividends as a necessary compensation made to investors for their contributed capital (Nelson and Winter, 1982; Lockett and Thompson, 2004; Penrose, 2009). Therefore, return on assets and profit margins as proxies inflate the resources generated in the growth process compared to the conceptualisations in growth process theories. To account for this conceptual difference, dividends paid must be disregarded in financing expenses when calculating accounting measures of company performance to compare them to financial statements. The *rate of dividend payment* can be determined by the venture's *equity employed* and the *cost of equity* (Equation 4-43). They are subtracted from the financing expenses (Equation 4-44).

$$\begin{aligned} \text{current rate of financing expenses} &\\ &= \text{rate of value creation} \\ &\quad * \text{share of value lost to providers of capital} \\ &\quad - \text{rate of divident payment} \end{aligned} \qquad \text{Eq 4-43}$$

$$\text{rate of divident payment} = \text{Equity employed} * \text{cost of equity} \qquad \text{Eq 4-44}$$

The equity employed is formalised as part of the firm managing subsystem below, while the cost of equity is formalised above.

4.2.3.2. Comparison to accounting performance measures

The reported revenue as a measure of value creation on the firm's income statement is already formalised in the value creation subsystem. The reported figures in this subsystem allow deriving the return on assets and net profit margin as accounting measures (Figure 4-20). They can be used as proxies for a company's ability to capture value and to test the model.

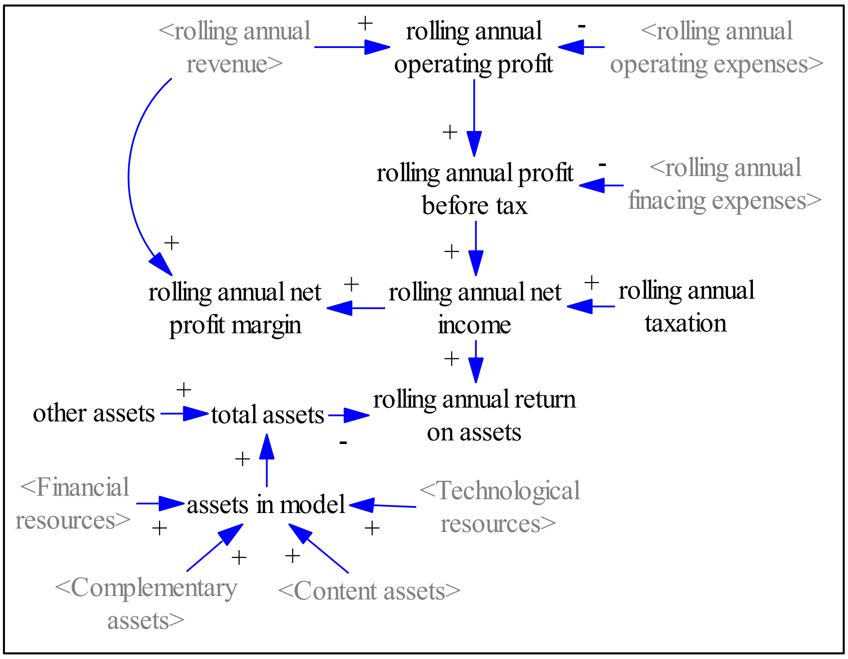


Figure 4-20: Return on assets and net profit margin

The *rolling annual operating profit* is the rolling annual revenue less the rolling annual operating expenses (Equation 4-45). The *rolling annual profit before tax* is the rolling annual operating profit less the rolling annual financing expenses (Equation 4-46). The *rolling annual net income* is calculated by subtracting the *rolling annual taxation* from the rolling annual profit before tax (Equation 4-47). The amount of taxes paid is an input from the venture's income statements. The *rolling annual return on assets* is calculated by dividing the net income by the *total assets* (Equation 4-48). Similarly, the venture's *rolling annual net profit margin* is calculated by dividing the venture's net income by its revenue (Equation 4-49).

$$\text{rolling annual operating profit} = \text{rolling annual revenue} - \text{rolling annual operating expenses} \quad \text{Eq 4-45}$$

$$\text{rolling annual profit before tax} = \text{rolling annual operating profit} - \text{rolling annual financing expenses} \quad \text{Eq 4-46}$$

$$\text{rolling annual net income} = \text{rolling annual profit before tax} - \text{rolling annual taxation} \quad \text{Eq 4-47}$$

$$\text{rolling annual return on assets} = \frac{\text{rolling annual net income}}{\text{total assets}} \quad \text{Eq 4-48}$$

$$\text{rolling annual net profit margin} = \frac{\text{rolling annual net income}}{\text{rolling annual revenue}} \quad \text{Eq 4-49}$$

The venture's *total assets* recognised on its balance sheet need to be determined to calculate return on assets. However, the conceptualisation of resources in the subsequent sections and those used to determine assets as balance sheet positions differ. A wide range of resources are considered in the model. However, a balance sheet considers only those resources that can be expressed in financial terms, i.e. those measured in amounts of money. Resources considered in the model in monetary amounts are *financial resources*, *technological resources*, *complementary assets*, and *content assets* (Equation 4-50). Other resources are considered in the model because they are relevant to the growth process and affect the performance outcomes such as human resources or the venture's product quality. However, these resources are not considered on a balance sheet and therefore not included when calculating the return on assets. On the other hand, the balance sheet may also include items not considered in the model, such as goodwill. These accounting measures are not considered relevant in growth process theories and do not affect value creation and capture (Grant, 1991; Penrose, 2009). These *other assets* are added to the balance sheet resources considered in the model to determine a return on assets figure comparable to financial statements (Equation 4-51).

$$\begin{aligned}\text{assets in model} = {} & \text{Financial resources} + \text{Complementary assets} \\ & + \text{Technological resources} + \text{Content assets}\end{aligned} \quad \text{Eq 4-50}$$

$$\text{total assets} = \text{assets in model} + \text{other assets} \quad \text{Eq 4-51}$$

The value of other assets is an input to the model imported from the venture's financial statements. The assets stocks included in the model are derived in the firm managing, technology developing, and content creation subsystems.

4.2.4. Overview of subsystem inputs

This section has contextualised, formalised, and specified value capture for digital ventures. In addition, the return on assets and the net profit margin have been calculated using the share of value captured. These accounting measures calculated in the model can be compared to ventures' financial statements to test the model (Table 4-2). In addition, this section has worked backwards from the share of value captured to identify the inputs required from other subsystems. These include the venture's resources considered in the technology development, content creation, and firm managing subsystems. Moreover, variables from the value creation subsystem weigh different shares of value captured, approximate switching costs, and derive accounting measures.

Table 4-2: Outputs and inputs of the value capture subsystem

<table>
<tr><th colspan="2">Outputs</th></tr>
<tr><td colspan="2">• Share of value captured as the theoretical performance measure
• Rolling annual return on assets and rolling annual net profit margin as accounting proxies for the share of value captured</td></tr>
<tr><th>Inputs from other subsystems</th><th>Exogenous inputs</th></tr>
<tr><td>Technology developing and content creation subsystems:
• Technological resources, rate of amortisation of technological resources
• Content assets, rate of amortisation of content assets
Firm managing subsystem:
• Marketing and selling employees, value delivering employees, technology developing employees, firm managing employees
• Equity employed, debt employed
• Complementary asset, rate of depreciation of complementary asset
• Financial resources
Value creation:
• Rate of value creation, rate of value creation for customers, rate of value creation for premium users
• Strength of product of customers, strength of product of users
• Customer usage intensity, user usage intensity
• New customer usage intensity, new user usage intensity
• Fraction of new customers, fraction of new premium users, premium user base, rate of premium user acquisition
• Premium product advantage</td><td>Business model designs:
• Customer contract period, premium user contract period
Environment – Competition:
• Strength of competitors and substitutes
• Number of competitors and substitutes
Environment – Input providers:
• Cost of value delivering inputs, cost of marketing and selling inputs, cost of technology developing inputs, cost of firm managing inputs
• Cost of equity, cost of debt
Accounting measures:
• Other assets, rolling annual taxation</td></tr>
</table>

In addition, the share of value captured depends on exogenous inputs regarding the business model design, environmental growth state inputs, and accounting measures. Firstly, the analyst needs to set contract terms for premium users and customers. Secondly, the analyst needs to evaluate the strength and number of competitors and substitute providers and set the costs of different resource inputs. Lastly, the model requires accounting measures that are not theoretically relevant to value creation and capture but ensure consistency of variables for testing purposes.

4.3. Technology development subsystem

Technological resources reflect the venture's software code that underpins its product or service. They determine the technological quality, one of the value drivers in the value creation subsystem. As conceptualised in the previous chapter, resources develop through activities, which rely on human resources and capabilities (Figure 4-21). Thus, the development activities rely on the venture's technology development capabilities and the employees made available by the firm's management. However, in a digital context, the established technology requires maintenance, which reduces the availability of employees for new development. These development and maintenance activities depend on the technological quality calculated in the value creation subsystem, the technology development capabilities, and the human resources in the firm managing subsystem.

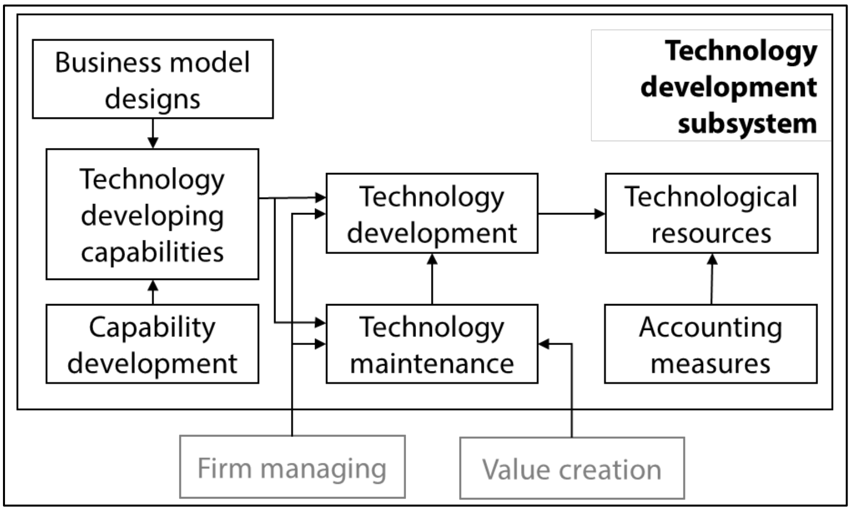


Figure 4-21: Technology development subsystem

The following subsections formalise the development of technological resources, the impact of technological development and technological maintenance activities, and the development of technology developing capabilities.

4.3.1. Technological resources

The model's stock of technological resources reflects the technological assets capitalised on the venture's balance sheet. These assets are an accounting measure of the accumulated development efforts regarding the software that underpins a venture's product or service (Arora, Fosfuri and Gambardella, 2001; Nambisan, 2017). They increase through investments into technology and decrease through amortisation (Figure 4-22).

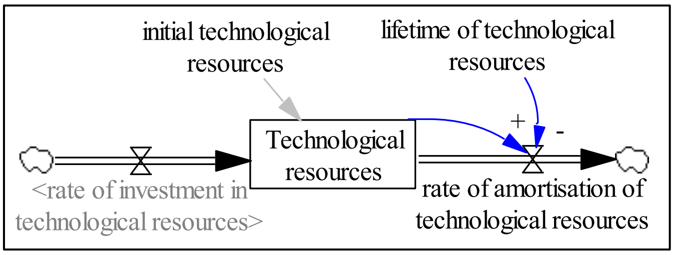


Figure 4-22: Technological resources

From their initial value, technological resources accumulate through investments and amortisation (Equation 4-52). The *rate of amortisation of technological* *resources* depends on the *lifetime of technological resources* (Knott, Bryce and Posen, 2003; Teece, 2007). For example, if a resource has an estimated lifetime of five years, one-fifth of the value is amortised every year. Therefore, the model calculates the amortisation rate by dividing the stock of technological resources by their lifetime (Equation 4-53).

$$\begin{aligned}\text{Technological resources} &\\ &= \text{initial technological resources}\\ &+ \int(\text{rate of investments in technology}\\ &- \text{rate of amortisation of technological resources})\end{aligned} \qquad \text{Eq 4-52}$$

$$\begin{aligned}\text{rate of amortisation of technological resources} &\\ &= \frac{\text{technological resources}}{\text{lifetime of technological resources}}\end{aligned} \qquad \text{Eq 4-53}$$

The initial technological resources are derived from the venture's financial statements. The resources in monetary amounts are indexed with the initial rate of value creation being one. Similarly, the lifetime in years is an exogenous input derived from the firm's financial statement. This approach is consistent with previous System Dynamics models such as the one developed by Huang and Kunc (2012), who developed a generic model for start-ups, and Oliva, Sterman, and Giese (2003), who developed a model replicating the growth of e-commerce companies. The rate of investments into technology is considered in the next subsection.

4.3.2. Technology development activities

Digital ventures' technology developing activities create their technological resources. Technology developing activities in a digital context relate to product improvements generated through software development, for example, by programming additional features (Bontis and Chung, 2000; Harmon, Raffo and Faulk, 2004; Baliyan and Kumar, 2014; Teece, 2018; Zaheer *et al.*, 2019). Moreover, in a digital context, the created technology requires continuous maintenance.

4.3.2.1. Technology development

The model defines technological resources as those resources capitalised on the venture's balance sheet. Therefore, the rate of investment in technology reflects the rate at which capital is invested into technological resources. The venture records those investments as capitalised software development expenses on its cash flow statement (Afuah and Tucci, 2000; Ruutu, Casey and Kotovirta, 2017; Teece, 2018). The model implements Sterman's (2000) resource-productivity-flow relationship to formalise activities, including technology development. The flow of technological investments depends on the executing resources and their productivity. The resources are the available development time of the venture's technology developing employees. Their productivity is represented by their ability to develop technology (Figure 4-23).

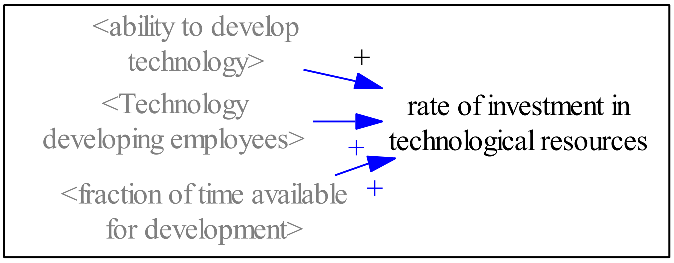


Figure 4-23: Technology development

The model calculates the *rate of investment in technology* by multiplying together the *technology developing employees*, their *fraction of time available for development*, and the *ability to develop technology* (Equation 4-54).

$$\text{rate of investment in technology} = \text{Technology developing employees} * \text{fraction of time available for development} * \text{ability to develop technology} \quad \text{Eq 4-54}$$

The number of technology developing employees is determined in the firm managing subsystem. The ability of each employee to develop technology is formalised as a capability below. The fraction of time available for development is determined by the firm's technology maintenance requirements.

4.3.2.2. Technology maintenance

Physical products are not usually altered by the development team after the product has been manufactured and shipped. Rather, the development team will develop a new version or different product. However, digital products and services are never finalised. Instead, software is altered continuously even after it has been sold and while the customer is using it due to two reasons. Firstly, digital products and services often include programming errors or security problems fixed over time (Sosa, Browning and Mihm, 2007; Rahmandad and Weiss, 2009; Woodard *et al.*, 2013; Zhang and Niu, 2013; Cristofaro, 2020). Secondly, because digital products and services are open and interact with a range of other software such as operating systems, a change in these related products or services may require updating the venture's product (Nambisan, 2017; von Briel, Recker and Davidsson, 2018; Zaheer *et al.*, 2019; Cristofaro, 2020). The venture's technology developing employees thus spend time debugging and updating existing features. This requirement reduces the time available for new developments. The more sophisticated the venture's existing technology, the more time will be spent on debugging and updating. The venture's technology developing employees execute this maintenance based on their capacity to maintain the technology (Figure 4-24).

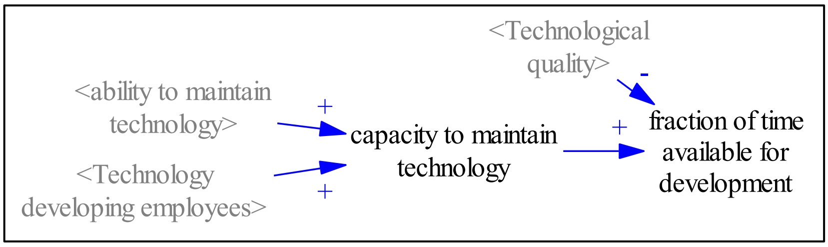


Figure 4-24: Technology maintenance and time for development

This *capacity to maintain technology* depends on the venture's number of *technology developing employees* and their *ability to maintain technology* (Equation 4-55). It reflects the technological quality the employees can maintain. The excess over capacity is available for new developments. The model calculates the available time fraction by expressing the difference between the capacity and quality as a fraction of the capacity (Equation 4-56). The equation is stable under extreme conditions: When there is no technology yet, employees can spend their entire time developing new technology. The max function ensures that the fraction of time does not turn negative when capacity is insufficient. In such cases, no time is available for new development.

$$\begin{aligned}&\text{capacity to maintain technology} \\ &\quad = \text{Technology developing employees} \\ &\quad * \text{ability to maintain technology}\end{aligned} \qquad \text{Eq 4-55}$$

$$\begin{aligned}&\text{fraction of time available for development} \\ &\quad = \text{MAX}(0, \text{ZIDZ}(\text{capacity to maintain technology} \\ &\quad - \text{Technological quality}, \text{capacity to maintain technology}))\end{aligned} \qquad \text{Eq 4-56}$$

The firm's management determines the technology developing employees. The existing technological quality is calculated in the value creation subsystem, and the ability to maintain technology is formalised below.

4.3.3. Technology development capabilities

In the model conceptualisation chapter, capabilities as measures of productivity depend on employee competence to execute activities and the adequacy of complementary assets (Subsection 3.2.3). While the average employee's competence improves through learning, it erodes when hiring new employees (Slater, 1980; Garnsey, 1998; Tan and Mahoney, 2005; Hugo and Garnsey, 2005; Stam, Garnsey and Heffernan, 2006; Stam and Garnsey, 2007; Penrose, 2009; Gabrielsson and Gabrielsson, 2013; Miozzo and DiVito, 2016; Harbermann and Schuilte, 2017; Hesse and Sternberg, 2017). This general logic has been applied to employees' technology developing competence with their ability to develop new and maintain existing technology (Figure 4-25) [14].

[14] The same structure has also been applied to model the capabilities of marketing and selling, value delivering, and firm managing employees. Appendix A illustrates these additional structures to avoid repetition.

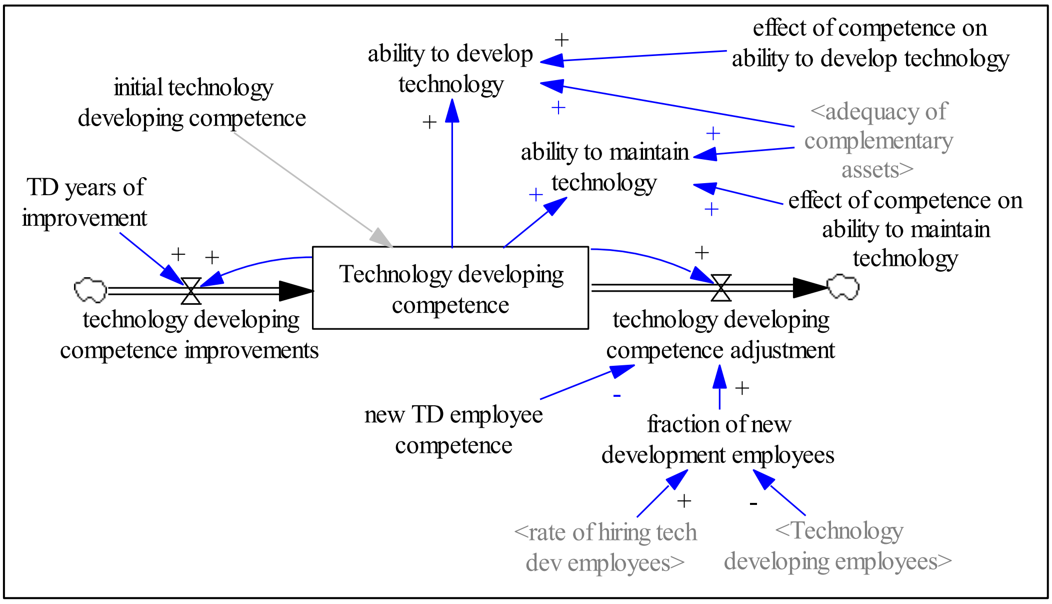


Figure 4-25: Technology developing capabilities

The model uses the structure proposed by Warren (2002) for employee skills and their impact on resources to formalise capabilities. The structure has been selected because it fits well to the theoretical underpinnings of growth paths theory, including capability improvement through learning and destruction through hiring. Warren proposes that the skill of the average employee in the firm can be represented as a qualitative variable on a scale from zero to one. The average employee's competence develops through *technology developing competence improvements* and a *technology developing competence adjustment* for new employees (Equation 4-57).

$$\begin{aligned}\text{Technology developing competence} \\ &= \text{initial technology developing competence} \\ &+ \int (\text{technology developing competence improvements} \\ &- \text{technology developing competence adjustment})\end{aligned} \qquad \text{Eq 4-57}$$

The competence improvements slow down as the employees move towards the maximum possible competence of one. This has been implemented by Sterman's (2000) s-curve (Equation 4-58). As in previous implementations of the s-curve, the model calculates the improvement rates using a standard rate adjusted for two factors. The standard rate is the inverse of the technology developing *(TD) years of improvement* required to achieve full competence levels. While the improvement speeds up initially as the competence levels improve, it slows down as employees move towards the maximum possible. The competence is also adjusted when the firm hires new employees. The magnitude of the reduction depends on the *fraction of new development employees* and *new TD employee competence* (Equation 4-59, 4-60). If the venture hires no new employees, no adjustment takes place. If the venture replaces all employees, the capability is adjusted to reflect the capability of new employees.

$$\begin{aligned}\text{technology developing competence improvements} \\ &= (1/\text{TD years of improvement}) \\ &\quad * \text{Technology developing competence} * (1 \\ &\quad - \text{Technology developing competence})\end{aligned} \qquad \text{Eq 4-58}$$

$$\begin{aligned}\text{technology developing competence adjustment} \\ &= (\text{Technology developing competence} \\ &\quad - \text{new TD employee competence}) \\ &\quad * \text{fraction of new development employees}\end{aligned} \qquad \text{Eq 4-59}$$

$$\begin{aligned}\text{fraction of new development employees} \\ &= \text{XIDZ}(\text{rate of hiring tech dev employees}, \\ &\quad \text{Technology developing employees}, 1)\end{aligned} \qquad \text{Eq 4-60}$$

The employees' abilities are calculated based on their competence. This requires scaling the competence from a dimensionless scale between zero and one to a quantitative, hard ability. Warren (2002) uses effect variables to scale the competence level to hard variables. This approach has also been used in the model. The *effect of competence on ability to develop technology* and the *effect of competence on ability to maintain technology* convert the employees' average competence as a soft variable to their ability to develop and maintain the technology. Thereby, these effect sizes reflect the best possibly efficiency of the venture's business model design in the activity-based view on business models (Warren, 2000, 2002; Zott and Amit, 2010). They represent the best practice throughput of the venture's activities when fully developed capabilities are achieved. The hard abilities express, for example, the technology capitalised per employee per period. In addition, the model considers the adequacy of complementary assets when calculating abilities (Equation 4-61, 4-62). This adequacy expresses the fraction of adequately equipped employees.

$$\begin{aligned}\text{ability to develop technology} \\ &= \text{Technology developing competence} \\ &* \text{effect of competence on ability to develop technology} \\ &* \text{adequacy of complementary assets}\end{aligned} \qquad \text{Eq 4-61}$$

$$\begin{aligned}\text{ability to maintain technology} \\ &= \text{Technology developing competence} \\ &* \text{effect of competence on ability to maintain technology} \\ &* \text{adequacy of complementary assets}\end{aligned} \qquad \text{Eq 4-62}$$

The initial competence and new employee competence is assessed based on the capability maturity model (see Paulk *et al.*, 1993) and descriptions of the venture's processes in annual reports. Some companies provide a time in years required to train new employees, which is used for the rate of improvement. Otherwise, the analyst sets the time required based on the training time of equally mature companies. The effects that transform the capability from soft to hard variables are set using Vensim's automatic model calibration.

4.3.4. Overview of subsystem inputs

This section has contextualised, formalised, and specified the subsystem through which digital ventures' technological resources develop. The outcome of this subsystem is the venture's stock of technological resources (Table 4-3). They can be compared to a case company's capitalised development expenses on its balance sheet. They develop through investments and amortisation, which are also used in other subsystems. The venture's technology developing activities and capabilities depend on its employees, complementary assets, and its existing technological quality. These inputs are determined by the venture's management and in the value creation subsystem.

Table 4-3: Outputs and inputs of the technology development subsystem

Outputs	
• Technological resources	
Inputs from other subsystems	**Exogenous inputs**
Firm managing subsystem: • Technology developing employees, rate of hiring value delivering employees • Adequacy of complementary assets **Value creation subsystem:** • Technological quality	**Capability development:** • Initial technology developing competence • TD years of improvement • New TD employee competence **Business model design:** • Effect of competence on ability to develop technology, effect of competence on ability to maintain technology **Accounting measures:** • Initial technological resources • Lifetime of technological resources

In addition, the technology development subsystem relies on a range of inputs set by the analyst based on accounting measures like the initial technological resources and their lifetime. Moreover, inputs regarding the development of capabilities and business model design are required. These include initial capability levels, improvement times, and effect sizes.

4.4. Customer and user subsystem

Customer and user bases are another critical resource for digital ventures. These customers and users may use the venture's software product or engage with another on its platform (Kollmann, 2006; Muzellec, Ronteau and Lambkin, 2015; Standing and Mattsson, 2016; Huang *et al.*, 2017). The outcomes of this subsystem are the indexed numbers of customers, users, and premium users (Figure 4-26). They are inputs to the value creation subsystem as the target of value creation and as a driver of network effects. The customer and user bases increase through the venture's marketing and selling activities and world-of-mouth marketing. They decrease depending on the customer lifetime, which depends on the venture's ability to deliver value. In addition, the development of the customer and user bases depends on variables related to customer and user behaviour and competition in the external environment. The abilities to acquire and deliver value to customers and users depends on respective employee capabilities.

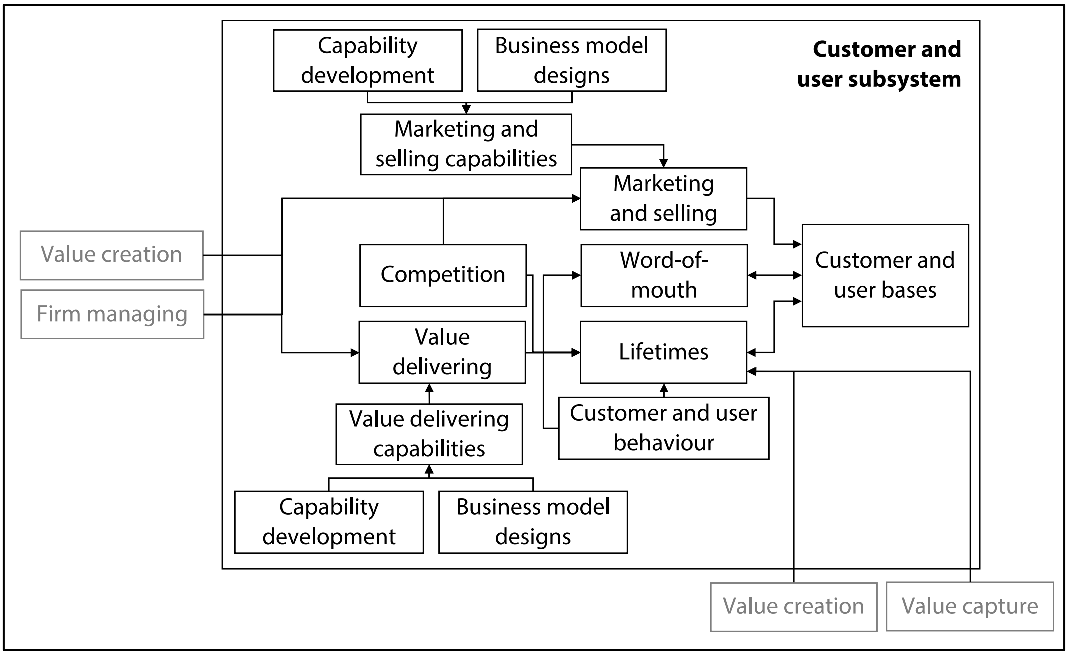


Figure 4-26: Customer and user subsystem

In the following sections, the customer and user bases are formalised. Their development through marketing and selling activities, word-of-mouth marketing, the customer lifetime, and value delivering activities are illustrated.

4.4.1. Customer and user bases

As the performance outcomes sections describe, some digital ventures such as multi-sided platforms distinguish between users and customers. Other digital ventures may distinguish between users and premium users (Afuah and Tucci, 2000; Kollmann, 2006; Teece, 2010; Zott, Amit and Massa, 2011; Roma and Dominici, 2016; Voigt and Hinz, 2016; Möller *et al.*, 2020). The model presented in this thesis distinguishes between customers, users, and premium users to account for these different business model designs (Figure 4-27). These different bases accumulate through marketing, word-of-mouth, and churn. Additionally, users and premium users may convert into another category (Gary *et al.*, 2008; Wagner, Benlian and Hess, 2014; Holm and Günzel-Jensen, 2017; Gu, Kannan and Ma, 2018).

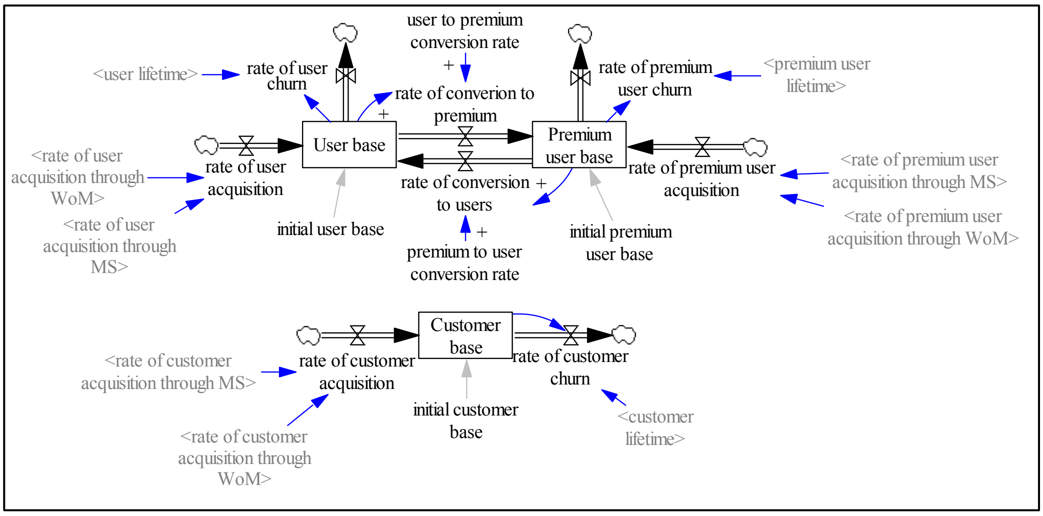


Figure 4-27: Customer and user bases

The venture's *user base*, *premium user base*, and *customer base* reflect the number of users of each type using the venture's product or service at a point in time. The sum of all bases is indexed at one at the beginning of the simulation to ensure the indexing of the rate of value creation. If the type is not present for a venture, the respective base has a value of zero. The relevant bases accumulate through their respective rates of acquisition and churn. Moreover, users and premium users are affected by conversion rates into the other category (Equation 4-63, 4-64, 4-65).

$$\text{User base} = \text{initial user base} + \int (\text{rate of user acquisition} + \text{rate of conversion to users} - \text{rate of converion to premium} - \text{rate of user churn}) \qquad \text{Eq 4-63}$$

$$\text{Premium user base} = \text{initial premium user base} + \int (\text{rate of premium user acquisition} + \text{rate of converion to premium} - \text{rate of conversion to users} - \text{rate of premium user churn}) \qquad \text{Eq 4-64}$$

$$\text{Customer base} = \text{initial user base} + \int (\text{rate of customer acquisition} - \text{rate of customer churn}) \qquad \text{Eq 4-65}$$

The *rate of conversion to premium* reflects the annualised number of users that switch to the upgraded version of the product. However, premium users may also drop the upgraded version. The annualised number of users that exchange the premium for the standard version of the product is reflected in the *rate of conversion to users*. Each rate decreases its originating stock while it increases its target stock. Both rates of conversion depend on the stock of users from which they convert and the *user to premium conversion rate* and *premium to user conversion rate*. These rates express, respectively, the fraction of users or premium who switch per period (Equation 4-66, 4-67).

$$\text{rate of conversion to premium} = \text{User base} * \text{user to premium conversion rate} \qquad \text{Eq 4-66}$$

$$\text{rate of conversion to users} = \text{Premium user base} * \text{premium to user conversion rate} \qquad \text{Eq 4-67}$$

Users, premium users, and customers may stop using the venture's product or service. The *rate of user churn*, *rate of premium user churn*, and *rate of customer churn* express the annualised number at which the respective type stops using the product. These rates decrease their respective customer and user bases. They depend on the *customer lifetime, user lifetime, and premium user lifetime.* These lifetimes measure the average number of years a user stays with the venture (Oliva, Sterman and Giese, 2003; Hadiji *et al.*, 2014; Runge *et al.*, 2014). This loss of customers and users is formalised like the amortisation in the technology development subsystem. The model calculates the churn of users and customers by dividing the respective user or customer base by the respective lifetime (Equation 4-68, 4-69, 4-70).

$$\text{rate of user churn} = \text{ZIDZ}(\text{User base}, \text{user lifetime}) \qquad \text{Eq 4-68}$$

$$\text{rate of premium user churn} = \text{ZIDZ}(\text{Premium user base}, \text{premium user lifetime}) \qquad \text{Eq 4-69}$$

$$\text{rate of customer churn} = \text{ZIDZ}(\text{Customer base}, \text{customer lifetime}) \qquad \text{Eq 4-70}$$

The *rate of user acquisition*, *rate of premium user acquisition*, and *rate of customer acquisition* are outcomes of two mechanisms. Firstly, the marketing and selling (MS) activities executed by the venture's employees (Oliva, Sterman and Giese, 2003; Huang *et al.*, 2017). Secondly, word-of-mouth (WoM) marketing, in which the venture's existing customers and users acquire further ones (Mikalef, Giannakos and Pateli, 2013; Huang *et al.*, 2017). The respective acquisition rates are the sum of the customers and users acquired through these two mechanisms (Equation 4-71, 4-72, 4-73).

$$\begin{aligned}\text{rate of user acquisition} \\ &= \text{rate of user acquisition through MS} \\ &+ \text{rate of user acquisition through WoM}\end{aligned} \qquad \text{Eq 4-71}$$

$$\begin{aligned}\text{rate of premium user acquisition} \\ &= \text{rate of premium user acquisition through MS} \\ &+ \text{rate of premium user acquisition through WoM}\end{aligned} \qquad \text{Eq 4-72}$$

$$\begin{aligned}\text{rate of customer acquisition} \\ &= \text{rate of customer acquisition through MS} \\ &+ \text{rate of customer acquisition through WoM}\end{aligned} \qquad \text{Eq 4-73}$$

The subsections below discuss the acquisition of customers and users through marketing and selling, through word-of-mouth marketing, and their respective lifetime.

4.4.2. Marketing and selling

Like providers of physical product, digital ventures may rely on a broad range of marketing and sales techniques. Consumer businesses may be able to acquire many customers with a limited number of employees through digital marketing. Business-to-business ventures may rely on non-digital sales techniques like trade shows or direct marketing (Reuber and Fischer, 2011; Tyrväinen and Selin, 2011). Because digital ventures may distinguish between customers, users, and premium users (Rangaswamy *et al.*, 2020), marketing and sales are directed at acquiring these three groups. Therefore, the adapted and detailed marketing and selling activities consider that the venture's employees may acquire these different groups. The model also considered managerial priorities to acquire the different groups (Figure 4-28).

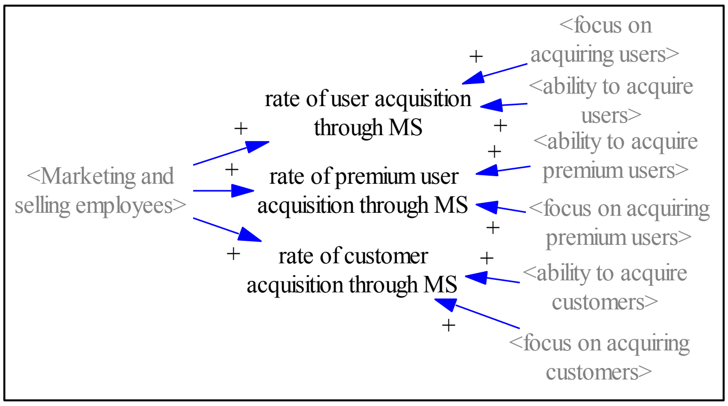


Figure 4-28: Marketing and selling activities

As for technology developing activities, the model implements Sterman's (2000) resource-productivity-flow relationship to formalise marketing and selling. The *rate of customer acquisition through marketing and selling*, and the other rates, reflect the number of indexed customers the venture acquires per period. Each rate depends on the *marketing and selling employees*, the *focus to acquire* the respective type, and *ability to acquire* the type (Equation 4-74, 4-75, 4-76). The abilities reflect the rate at which the average indexed employee acquires the different customer types. The priorities reflect the fraction of time spent on acquiring each type.

$$\text{rate of user acquisition through MS} = \text{Marketing and selling employees} * \text{ability to acquire users} * \text{focus on acquiring users} \qquad \text{Eq 4-74}$$

$$\text{rate of premium user acquisition through MS} = \text{Marketing and selling employees} * \text{ability to acquire premium users} * \text{focus on acquiring premium users} \qquad \text{Eq 4-75}$$

$$\text{rate of customer acquisition through MS} = \text{Marketing and selling employees} * \text{ability to acquire customers} * \text{focus on acquiring customers} \qquad \text{Eq 4-76}$$

The abilities to acquire customers, users, and premium users depend on the competence of the venture's marketing and selling employees.[15] The priorities are formalised in the firm managing subsystem.

4.4.3. Word-of-mouth marketing

Companies offering physical products may already benefit from word-of-mouth marketing. Their customers may recommend the product and thereby acquire further customers. Some digital ventures offering their product and services to consumers may benefit particularly from it. On the one hand, the reach and ease of accessing digital products makes the adoption for new customers quicker. On the other hand, network effects incentivise existing users and customers to refer and recommend digital products (Song, Parry and Kawakami, 2009; Reuber and Fischer, 2011; Mikalef, Giannakos and Pateli, 2013; Roma and Dominici, 2016; Kuester, Konya-Baumbach and Schuhmacher, 2018; Zaheer, 2020). This word-of-mouth marketing depends on the existing customer and user bases and the number of new users and customers that each existing one acquires (Figure 4-29).

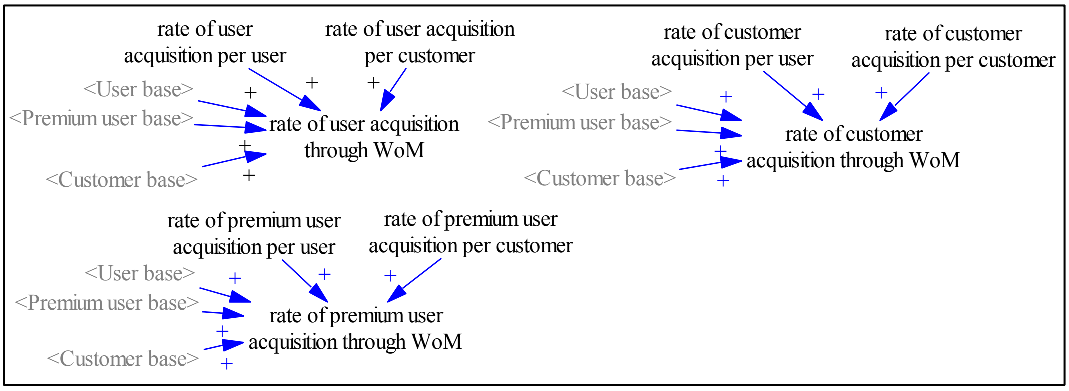


Figure 4-29: Customer and user acquisition through word-of-mouth

The model calculates the *rate of customer acquisition through WoM* by multiplying the number of customers and users with the rates at which each existing customer and user acquires new customers (Equation 4-77). It uses the

[15] These are formalised similarly to the technology developing competence. This specific capability is not formalised again but presented in Appendix A to avoid repetition.

same principles to derive users' and premium users' WoM acquisition rates (Equation 4-78, 4-79).

$$\begin{aligned}\text{rate of customer acquisition through WoM} \\ &= \text{Customer base} \\ &* \text{rate of customer acquisition per customer} \\ &+ (\text{User base} + \text{Premium user base}) \\ &* \text{rate of customer acquisition per user}\end{aligned} \qquad \text{Eq 4-77}$$

$$\begin{aligned}\text{rate of user acquisition through WoM} \\ &= \text{Customer base} \\ &* \text{rate of user acquisition per customer} + (\text{User base} \\ &+ \text{Premium user base}) \\ &* \text{rate of user acquisition per user}\end{aligned} \qquad \text{Eq 4-78}$$

$$\begin{aligned}\text{rate of premium user acquisition through WoM} \\ &= \text{Customer base} \\ &* \text{rate of premium user acquisition per customer} \\ &+ (\text{User base} + \text{Premium user base}) \\ &* \text{rate of premium user acquisition per user}\end{aligned} \qquad \text{Eq 4-79}$$

The customer and user bases are calculated above. The analyst sets the rates of acquisition per customer and user based on information provided in annual reports. They reflect the number of indexed users or customers acquired by each existing indexed user or customer per period.

4.4.4. Customer lifetime

The customer lifetime reflects the number of years that the average customer maintains his relationship with the venture and uses its product[16]. As discussed in the value capture subsystem, some digital ventures lock customers into long-term contracts. The length of those contracts provides a minimum customer lifetime (Ruutu, Casey and Kotovirta, 2017). Above this minimum length, the customer lifetime depends on the competition and service adequacy of the venture (Figure

[16] The supplementary material regarding this subsystem in Appendix A uses the same structure to derive the user lifetime and premium user lifetime.

4-30). For example, more customers will drop the venture's product when competitors or providers of substitutes improve their products. Additionally, the venture needs to ensure that it has sufficient capacity to service customers and users adequately. For example, if a SaaS product is not available or customer service is insufficient, more customers will drop the product (Warren, 2002; Oliva, Sterman and Giese, 2003; Currie, Joyce and Winch, 2007; Tyrväinen and Selin, 2011; Zhao, Song and Storm, 2013; Voigt and Hinz, 2016).

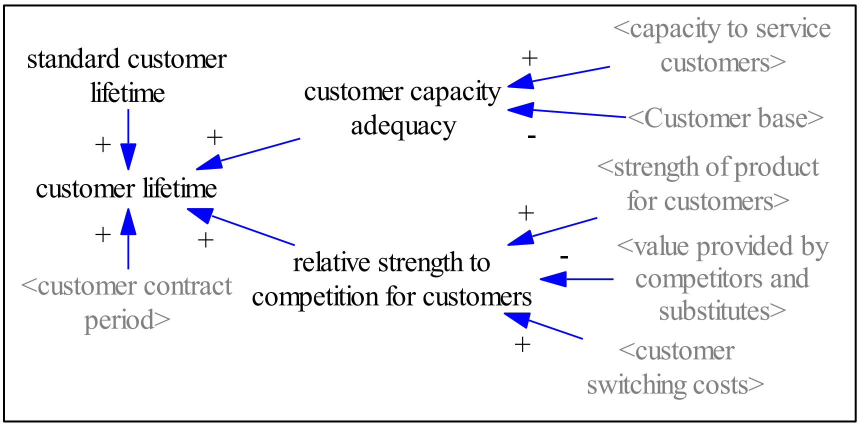


Figure 4-30: Customer lifetime

The model uses Sterman's (2000) structure for multiplicative effects to formalise the customer lifetime by adjusting a *standard customer lifetime* for two effects. The model adjusts it for the *customer capacity adequacy* and the *relative strength to competition for customers*. In addition, it sets the *customer contract period* as a minimum lifetime (Equation 4-80).

$$\begin{aligned}&\text{customer lifetime} \qquad\qquad \text{Eq 4-80}\\&= \text{MAX}(\text{customer contract period}, \text{standard customer lifetime}\\&* \text{customer capacity adequacy}\\&* \text{relative strength to competition for customers})\end{aligned}$$

The customer capacity adequacy reflects the fraction of its customers that the venture can adequately service. It is calculated by dividing the *capacity to service customers* by the *customer base*. In cases where the capacity exceeds the customer base, the adequacy has been capped at one (Equation 4-81). The relative strength to competition for customers expresses the strength of the venture's product, including switching costs, compared to competitors and substitutes

(Equation 4-82). The model formalises this relationship using the equations employed for the bargaining power in the value capture subsystem. It ensures that the equation works for extreme values. For example, the customer lifetime remains at its standard value if there is no competition and reduces to the contract period as competition increases.

$$\text{customer capacity adequacy} = \text{MIN}\,(1, \text{ZIDZ}(\text{capacity to service customers}, \text{Customer base})) \qquad \text{Eq 4-81}$$

$$\begin{aligned}&\text{relative strength to competition for customers} \qquad \text{Eq 4-82}\\&= \text{ZIDZ}(\text{strength of product for customers}\\&* (1 + \text{customer switching costs}), \text{strength of product for customers}\\&* (1 + \text{customer switching costs})\\&+ \text{value provided by competitors and substitutes})\end{aligned}$$

The strength of the product for customers is calculated in the value creation subsystem. The switching costs and value provided by competitors and substitutes are calculated in the value capture subsystems. The customer base is discussed above, while the ability to service customers is discussed below as part of the venture's value delivering activities. The Vensim software sets the standard customer lifetime using automatic model calibration.

4.4.5. Value delivering activities

Because the fully digital products considered in this thesis are non-physical, digital ventures do not require inventories or manufacturing capacities considered part of the value delivering activities for physical products (Afuah and Tucci, 2000; Hull *et al.*, 2007; Hafezieh, Akhavan and Eshraghian, 2011; Bradley *et al.*, 2012). Instead, digital ventures' capacity constraint depends on their ability to host their product and service their customers and users appropriately (Afuah and Tucci, 2000; Oliva, Sterman and Giese, 2003; Liao *et al.*, 2015; Kohtamäki *et al.*, 2019). The capacities to service customers and users depend on the venture's value delivering employees, their abilities to service customers and users, and their focus on servicing each type (Figure 4-31).

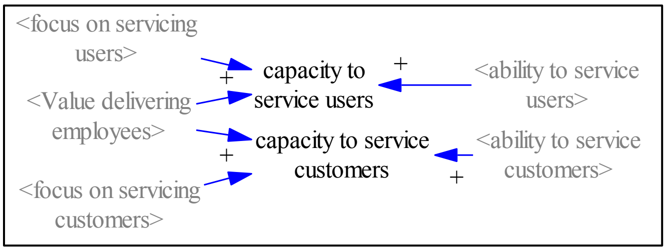


Figure 4-31: Value delivering activities

The *capacity to service customers* reflects the number of indexed customers the venture can adequately service. The model calculates it by multiplying the venture's *value delivering employees*, their *ability to service customers*, and their *focus on servicing customers* (Equation 4-83). While the ability reflects how many customers each employee can service, the focus reflects the fraction of time spent servicing customers. The model applies the same principles to the *capacity to service users*, which reflects the indexed number of users and premium users the venture can service adequately (Equation 4-84).

$$\text{capacity to service customers} = \text{Value delivering employees} * \text{ability to service customers} * \text{focus on servicing customers} \quad \text{Eq 4-83}$$

$$\text{capacity to service users} = \text{Value delivering employees} * \text{ability to service users} * \text{focus on servicing users} \quad \text{Eq 4-84}$$

The model determines the venture's value delivering employees and their focus in the firm managing subsystem. The abilities to service users and customers depend on the employee competences. It is formalised like the technology development competence in Appendix A.

4.4.6. Overview of subsystem inputs

This subsystem has formalised the processes through which the venture's customer base, user base, and premium user base develop (Table 4-4). The total of all customer and users is indexed at one. These bases then develop through the venture's marketing and selling activities, word-of-mouth marketing, and customer churn. The model requires a range of inputs from other subsystems to calculate these flows. These include the employees engaged in the firm's marketing and value delivering activities, their hiring rates, and priorities. Additionally, variables from the value creation and capture subsystem are required.

Table 4-4: Outputs and inputs of the customer and user subsystem

<table>
<tr><th colspan="2">Outputs</th></tr>
<tr><td colspan="2">• Customer base, user base, premium user base</td></tr>
<tr><th>Inputs from other subsystems</th><th>Exogenous inputs</th></tr>
<tr><td>Firm managing subsystem:
• Marketing and selling employees, Value delivering employees
• Rate of hiring marketing and selling employees, rate of hiring value delivering employees
• Focus on acquiring customers, focus on acquiring users, focus on acquiring premium users
• Focus on servicing users, priority on servicing customers
• Adequacy of complementary assets
Value creation subsystem:
• Strength of product for customers, strength of product for users
• Premium product advantage
Value capture subsystem:
• Value provided by competitors and substitutes
• Customer contract period, premium user contract period
• Customer switching costs, user switching costs</td><td>Environment – Customer and user behaviour:
• Initial customer base, initial user base, initial premium user base
• User to premium conversion rate, premium to user conversion rate
• Rate of user acquisition per user, rate of user acquisition per customer, rate of premium user acquisition per user, rate of premium user acquisition per customer, rate of customer acquisition per user, rate of customer acquisition per customer
• Standard customer lifetime, standard user lifetime
Capability development:
• Initial marketing and selling competence, initial value delivering competence
• MS years of improvement, VD years of improvement
• New MS employee competence, new VD employee competence
Business model design:
• Effect of competence on ability to acquire customers, effect of competence on ability to acquire users, effect of competence on ability to acquire premium users
• Effect of competence on ability to service customers, effect of ability on ability to service users</td></tr>
</table>

The customer and user subsystem also depends on a range of input set by the analyst based on annual reports and variables set through automatic model calibration. The analyst needs to extract initial values, conversion rate, and word-of-mouth acquisition rates from annual reports. Standard lifetimes are then calibrated using the Vensim software. The analyst needs to set the variables related to capability development. These are the same types of variables already presented for the technology development capabilities. Lastly, the Vensim software is used to calibrate effect sizes that reflect the maximum throughput of a business model's activities.

4.5. Firm managing subsystem

The conceptualisation chapter illustrates that a digital venture's management is responsible for managing and expanding the firm's human resources, complementary assets, and financial resources. These outcomes are the inputs to the other subsystems described above. The three sections below illustrate these three managerial areas. They derive these outcomes by formalising how the management forms targets and implements them depending on their capabilities (Figure 4-32). The targets themselves depend on the capabilities in the other subsystems and the management's dominant logic.

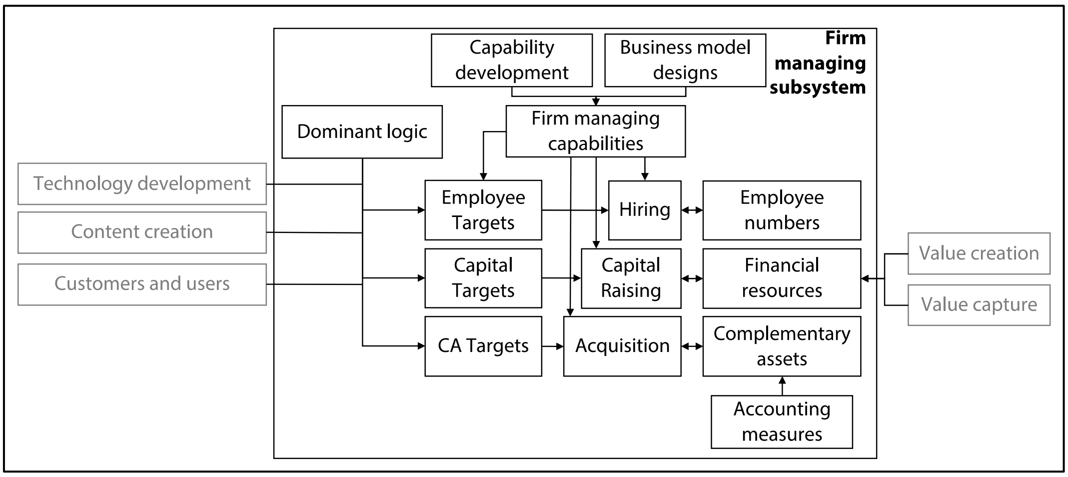


Figure 4-32: Firm managing subsystem

The first subsection covers the venture's human resource management. The subsequent subsections then cover its complementary assets and financial resources management.

4.5.1. Management of human resources

The venture may need to hire additional employees to achieve its growth and technology improvement goals. The employees across the venture's four activities are the first outcome of the firm managing subsystem. This section describes the formalisation of human resources using the example of marketing and selling employees[17]. It covers the stock of marketing and selling employees, influences on hiring employees, and the management's priorities for marketing and selling activities.

4.5.1.1. Marketing and selling employees

The model employs a structure that System Dynamics modellers often use to model employees (see Sterman, 2000; Morecroft, 2015). The structure adjusts the initial number of employees through outflows of employees leaving due to lay-offs and turnover and an inflow of new employees through hiring (Figure 4-33).

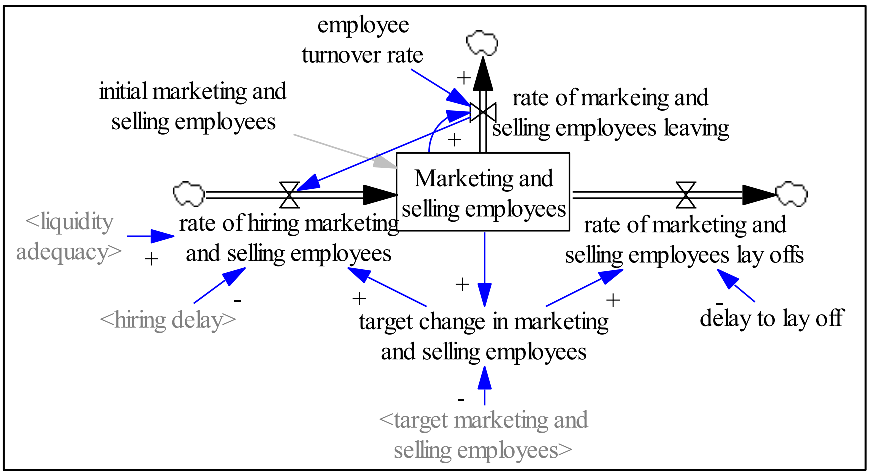


Figure 4-33: Marketing and selling employees

The model indexed the number of *marketing and selling employees* at one at the beginning of the simulation. This number then accumulates through the rates of hiring, lay-offs, and employees leaving (Equation 4-85). The model uses the same equations to determine these flows as Sterman (2000) and Morecroft (2015) use. The number of employees leaving the organisation per period depends on the number of employees and the *employee turnover rate* (Equation 4-86). This rate reflects the fraction of employees that leave the company every year. The hiring and layoffs rates adjust the number of employees to the *target marketing and*

[17] Appendix A covers the other three types of human resource stocks to avoid repetition. These additional stocks regard the venture's value delivering, technology developing, and firm managing employees.

selling employees. The number of employees that need to be hired or laid off is expressed by the *target change in marketing and selling employees*. The model calculates it as the difference between the management's target and the current number of employees (Equation 4-87). If this difference is positive, the venture hires new employees over a *hiring delay* until the number of employees equals the target and the target change is zero. The previous chapter has also argued that the venture may delay its hiring until its fundraising efforts have secured sufficient financial resources for a planned expansion (Subsection 3.3.2). The *liquidity adequacy* adjusts the *rate of hiring marketing and selling employees* depending on the secured funding. Moreover, the venture needs to replace employees that left due to turnover (Equation 4-88). If the target change of employees is negative, the venture lays employees off through the *rate of marketing and selling employees lay offs* over the *delay to lay off* (Equation 4-89).

$$\begin{aligned}
&\text{Marketing and selling employees} \qquad \text{Eq 4-85}\\
&\quad = \text{initial marketing and selling employees}\\
&\quad + \int (\text{rate of hiring marketing and selling employees}\\
&\quad - \text{rate of marketing and selling employees lay offs}\\
&\quad - \text{rate of marketing and selling employees leaving})
\end{aligned}$$

$$\begin{aligned}
&\text{rate of marketing and selling employees leaving} \qquad \text{Eq 4-86}\\
&\quad = \text{Marketing and selling employees}\\
&\quad * \text{employee turnover rate}
\end{aligned}$$

$$\begin{aligned}
&\text{target change in marketing and selling employees} \qquad \text{Eq 4-87}\\
&\quad = \text{target marketing and selling employees}\\
&\quad - \text{Marketing and selling employees}
\end{aligned}$$

$$\begin{aligned}
&\text{rate of hiring marketing and selling employees} \qquad \text{Eq 4-88}\\
&= \text{MAX}(0, \text{target change in marketing and selling employees/hiring delay})\\
&* \text{liquidity adequacy} + \text{rate of markeing and selling employees leaving}
\end{aligned}$$

$$\begin{aligned}
&\text{rate of marketing and selling employees lay offs} \qquad \text{Eq 4-89}\\
&= \text{MAX}(0, -\text{target change in marketing and selling employees}\\
&/\text{delay to lay off})
\end{aligned}$$

The delay to lay off is set to 0.1 for all companies. The turnover rate is set based on companies' annual reports and publicly available information. The liquidity adequacy is discussed as part of the financial management below. The two subsequent subsections formalise the target employees and hiring delay that drive the firm's increase in human resources.

4.5.1.2. Target marketing and selling employees

The target marketing and selling employees capture the number of employees the management wants to employ to achieve its growth goals for customers, users, and premium users. Previous System Dynamics models have derived such targets based on the management's goals and the expected productivity of each employee (Sterman, 2000; Morecroft, 2015). The model implements these principles to determine all employee targets. Its target number of marketing and selling employees thus depends on the customer, user, and premium user growth goal and employees' abilities to acquire them (Figure 4-34). Moreover, as argued during model conceptualisation, some digital ventures may employ dominant logics that cap their employee numbers and are unwilling to hire more employees (Subsection 3.3.2).

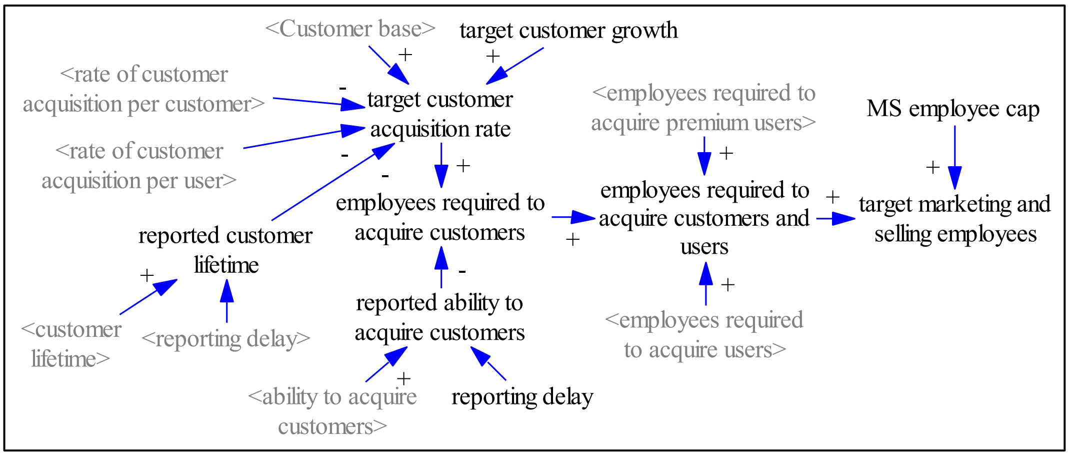


Figure 4-34: Target marketing and selling employees

The *target marketing and selling employees* are calculated by adjusting the *employees required to acquire customers and users* for the company's *MS employee cap* (Equation 4-90). If the company has not set a cap employee numbers (MS employee cap =-1), the company plans to hire all employees required to achieve its goals. Otherwise, it hires the smaller number of required employees or the cap (Davidsson, 1989; Kirkwood, 2009; Hesse and Sternberg, 2017). The *employees required to acquire customers and users* expresses the number of employees required to achieve the company's customer and user growth goals. The model calculates this number through the sum of employees required in order to achieve each of the marketing and selling goals being pursued (Equation 4-91).

$$\begin{aligned}\text{target marketing and selling employees} &= \text{IF THEN ELSE}\big(\text{MS employee cap} = -1,\\ &\text{employees required to acquire customers and users},\\ &\text{MIN}(\text{MS employee cap},\\ &\text{employees required to acquire customers and users})\big)\end{aligned} \qquad \text{Eq 4-90}$$

$$\begin{aligned}\text{employees required to acquire customers and users} &= \text{employees required to acquire customers}\\ &+ \text{employees required to acquire users}\\ &+ \text{employees required to acquire premium users}\end{aligned} \qquad \text{Eq 4-91}$$

The model bases its employee requirements on the principles of Sterman (2000) and Morecroft (2015). It calculates the number of employees required to achieve the venture's customer growth goal based on the goal's magnitude and the expected employee productivity[18]. The *target customer acquisition rate* and the *reported ability to acquire customers* reflect this goal and productivity (Equation 4-92). The reported ability to acquire customers captures the employees' *ability to acquire customers* but acknowledges that the managers do not know productivity levels accurately. Rather, its knowledge is affected by the *reporting delay.* As suggested by Sterman and Morecroft, the reported rate is derived using Vensim's smooth function (Equation 4-93). The rate at which the venture wants to acquire customers depends on the venture's current *customer base* and its annual *target customer growth*. However, its employees do not need to acquire customers generated through word-of-mouth by other users and customers (Equation 4-94). The venture must make up for customer loss through churn. The model

[18] Appendix A illustrated these equations for users and premium users to avoid repetition.

incorporates this expected churn through the *reported customer lifetime* that acknowledges the reporting delay (Equation 4-95).

$$\text{employees required to acquire customers} = \text{ZIDZ}(\text{target customer acquisition rate}, \text{reported ability to acquire customers}) \quad \text{Eq 4-92}$$

$$\text{reported ability to acquire customers} = \text{SMOOTH}(\text{ability to acquire customers}, \text{reporting delay}) \quad \text{Eq 4-93}$$

$$\text{target customer acquisition rate} = \text{Customer base} * (\text{target customer growth} + \text{ZIDZ}(1, \text{reported customer lifetime}) - \text{rate of customer acquisition per customer} - \text{rate of customer acquisition per user}) \quad \text{Eq 4-94}$$

$$\text{reported customer lifetime} = \text{SMOOTH}(\text{customer lifetime}, \text{reporting delay}) \quad \text{Eq 4-95}$$

For all companies, the reporting delay has been set at 0.25 to reflect common quarterly reporting intervals. The MS employees cap and target customer growth are set by reviewing the strategic and operational statements in the venture's annual reports. They express the venture's dominant logic during a growth state. The model uses the same structure and equations to determine the employees required to acquire the target number of users and premium users (see Appendix A).

4.5.1.3. Hiring delay

The hiring delay expresses the time it takes the venture to increase its employee number to its target. Like other activities in the previous subsystems, this outcome of the firm management activities depends on employee inputs and their productivity (Sterman, 2000). Here, the inputs are the available management time expressed by the management employees and their managerial slack. Their productivity is expressed through their ability to hire (Figure 4-35).

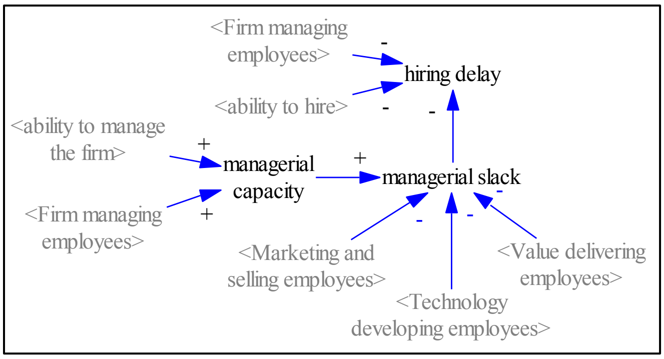


Figure 4-35: Managerial slack and hiring delay

The more *firm management employees* are employed by the venture, the higher the *managerial slack*, and the higher their *ability to hire*, the lower the hiring delay (Equation 4-96)[19]. The *managerial slack* expresses the time fraction available to the management to determine and execute growth plans, including hiring. It is the fraction of *managerial capacity* not occupied with managing the venture's operational employees (Equation 4-97). This managerial capacity depends on the available firm managing employees and their *ability to manage the firm* (Equation 4-98).

$$\text{hiring delay} = \text{XIDZ}(1, \text{Firm managing employees} * \text{managerial slack} * \text{ability to hire}, 100) \qquad \text{Eq 4-96}$$

$$\text{managerial slack} = \text{MAX}(0, (\text{managerial capacity} - (\text{Marketing and selling employees} + \text{Value delivering employees} + \text{Technology developing employees})) / \text{managerial capacity}) \qquad \text{Eq 4-97}$$

$$\text{managerial capacity} = \text{Firm managing employees} * \text{ability to manage the firm} \qquad \text{Eq 4-98}$$

[19] The XIDZ function prevents division by zero when the product of firm managing employee, managerial slack, and the ability to hire is zero. In such cases, no hiring should take place. The function returns a hiring delay of 100 (years). In light of the timeframe of a few years for which the model is used, this leads to a neglectable amount of hiring.

The different employee stocks follow the same structure explained here for marketing and selling employees. The ability to hire and the ability to manage the firm depend on the management employees' capabilities[20].

4.5.1.4. Priorities of marketing and selling employees

Digital ventures' marketing and selling employees face three potential goals. Therefore, the available employees must prioritise whether to spend time on marketing to customers, users, or premium users (Figure 4-36).

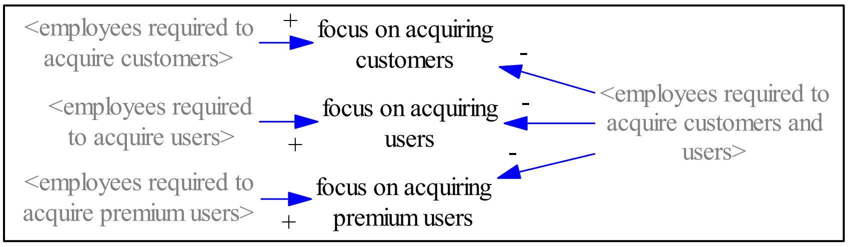


Figure 4-36: Priorities of marketing and selling employees

These three priorities are calculated by expressing the number of employees required to achieve a goal as a fraction of employees required to achieve all goals (Equation 4-99, 4-100, 4-101).

$$\text{focus on acquiring customers} = \text{employees required to acquire customers} / \text{employees required to acquire customers and users} \quad \text{Eq 4-99}$$

$$\text{focus on acquiring users} = \text{employees required to acquire users} / \text{employees required to acquire customers and users} \quad \text{Eq 4-100}$$

$$\text{focus on acquiring premium users} = \text{employees required to acquire premium users} / \text{employees required to acquire customers and users} \quad \text{Eq 4-101}$$

The marketing and selling activities in the customer and user subsystem use these priorities. When target and actual employees match and the management's

[20] These capabilities are formalised using the same structure illustrated in the technology development subsystems. They are not repeated here but in Appendix A to avoid repetition.

estimates about productivity levels are correct, these equations ensure that all goals are achieved. Otherwise, each goal is achieved at the same proportion.

4.5.2. Management of complementary assets

Capabilities rely on the provision of adequate equipment, reflected in the firm's complementary assets (Garnsey, 1998; Stam, Garnsey and Heffernan, 2006). The following section describes the development of the firm's complementary assets, their adequacy, and the formation of investment targets into them.

4.5.2.1. Complementary assets and their adequacy

The venture's complementary assets reflect its property and equipment on its balance sheet. For digital ventures, complementary assets may include, for example, servers to host the firm's website, and the equipment and software used by its employees (Rosemann, Andersson and Lind, 2011). Their adequacy depends on the required complementary assets and the assets held by the venture. The management can increase complementary assets by acquiring them. They then depreciate over time (Figure 4-37).

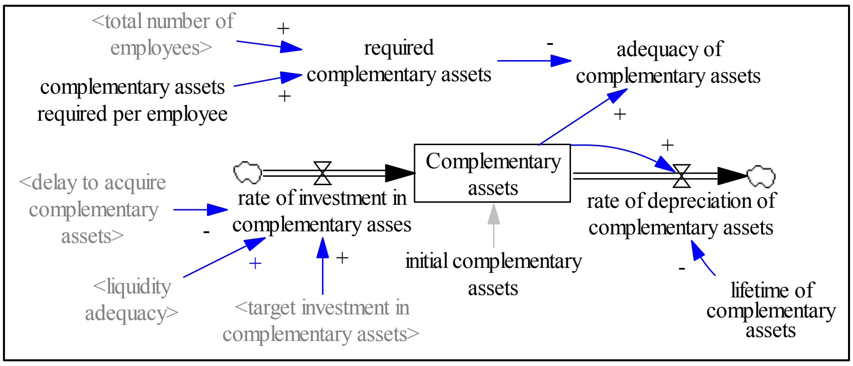


Figure 4-37: Complementary assets and their adequacy

The *adequacy of complementary assets* expresses the venture's *complementary assets* as a fraction of the *required complementary assets* capped at a value of one (Equation 4-102). The required complementary assets depend on the *total number of employees* and the *complementary assets required per employee* (Equation 4-103).

$$\text{adequacy of complementary assets} = \text{MIN}(1, \text{Complementary assets} / \text{required complementary assets}) \qquad \text{Eq 4-102}$$

$$\text{required complementary assets} = \text{total number of employees} * \text{complementary assets required per employee} \qquad \text{Eq 4-103}$$

The venture's complementary assets accumulate from their initial level through the *rate of investment in complementary assets* and the *rate of depreciation of complementary assets* (Equation 4-104). The depreciation rate is calculated through the same equations used for the amortisation of technological resources in the technology development subsystem. The model divides the complementary asset stock by the *lifetime of complementary assets* (Equation 4-105). The *rate of investment in complementary assets* is calculated like the rate of hiring human resources. The investment rate achieves a *target investment in complementary assets* over a *delay to acquire complementary assets*. It also accounts for the *liquidity adequacy*, which prevents investments before fundraising has been completed (Equation 4-106).

$$\text{Complementary assets} = \text{initial complementary assets} + \int (\text{rate of investment in complementary assets} - \text{rate of depreciation of complementary assets}) \qquad \text{Eq 4-104}$$

$$\text{rate of depreciation of complementary assets} = \text{Complementary assets} / \text{lifetime of complementary assets} \qquad \text{Eq 4-105}$$

$$\text{rate of investment in complementary assets} = (\text{target investment in complementary assets} / \text{delay to acquire complementary assets}) * \text{liquidity adequacy} \qquad \text{Eq 4-106}$$

The lifetime of complementary assets in years, the initial complementary assets, and the complementary assets per employee are exogenous inputs derived from the firm's financial statement. While the acquisition delay uses the same equations as the hiring delay (see Appendix A), the target investment is formalised below.

4.5.2.2. Target investment in complementary assets

When expanding the firm by hiring new employees, the venture must also acquire the complementary assets required to equip its increasing number of employees. Thus, it acquires the difference between the available complementary assets and those required for its target number of employees (Figure 4-38).

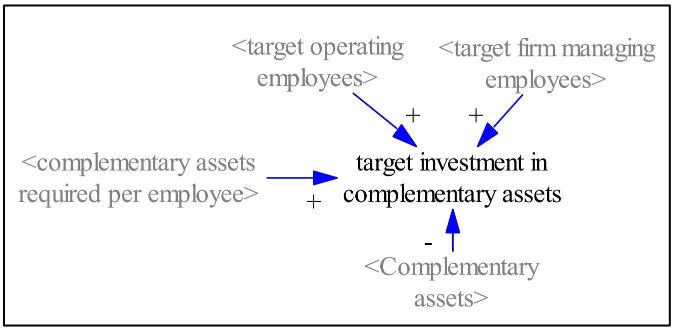


Figure 4-38: Target complementary assets

The required complementary assets for the firm, including its expansion, depend on the *target operating employees* and *target firm managing employees* as well as the *complementary assets required per employee*. The difference between the required and held *complementary assets* is acquired by the venture (Equation 4-107). This targeted investment cannot fall below zero if the venture holds excess complementary assets.

$$\begin{aligned} &\text{target investment in complementary assets} \\ &\quad = \text{MAX}(0, (\text{target operating employees} \\ &\quad + \text{target firm managing employees}) \\ &\quad * \text{complementary assets required per employee} \\ &\quad - \text{Complementary assets}) \end{aligned} \qquad \text{Eq 4-107}$$

The complementary assets held and required per employee have been introduced above. The target employee numbers are explained above for marketing and selling employees and Appendix A for all other employee types.

4.5.3. Management of financial resources

Besides managing the firm's human resources and complementary assets, the venture also needs to manage its financial resources and liquidity.

4.5.3.1. Financial resources

As for other ventures, financial resources refer to a venture's cash position on its balance sheet (Mudambi and Treichel, 2005; Kollmann, 2006). They increase through generating resources and raising capital (Figure 4-39). They deplete through investments into technological resources, complementary assets, and content assets (Hugo and Garnsey, 2001).

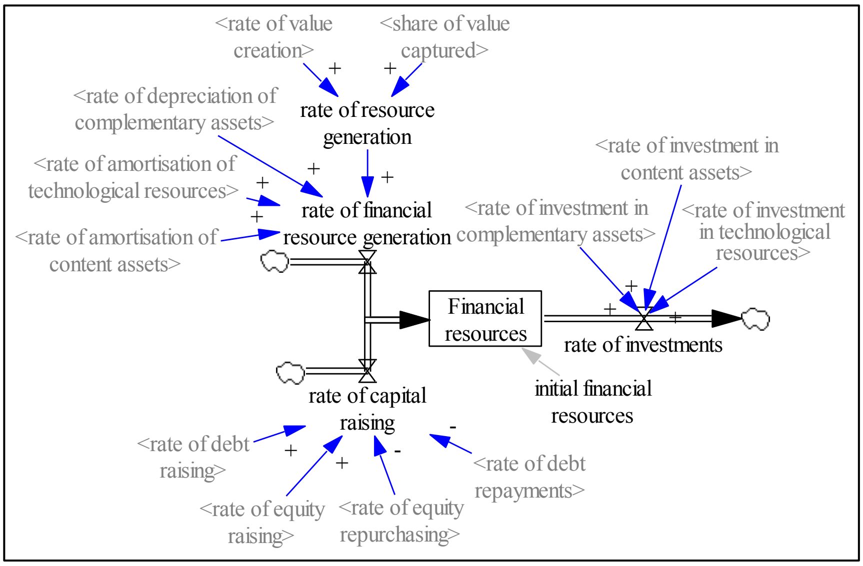


Figure 4-39: Financial resources

The venture's financial resources accumulate through the *rate of financial resources generation*, *rate of capital raising*, and *rate of investments* (Equation 4-108).

Financial resources Eq 4-108

$$= \text{initial financial resources} + \int (\text{rate of financial resource generation} + \text{rate of capital raising} - \text{rate of investments})$$

The financial resources generated reflect those resources received and maintained by the venture in the form of cash. The *rate of resource generation* measures the absolute rate of change in balance sheet resources (Teece, 1986; Garnsey, 1998; Hugo and Garnsey, 2001, 2002; Garnsey, Stam and Heffernan, 2006; Zott and Amit, 2007, 2010; Garnsey, Lubik and Heffernan, 2015). The model calculates it by multiplying together the *rate of value* creation and the *share of value captured* (Equation 4-109). However, the share of value captured includes non-cash expenses such as depreciation and amortisation (Nelson and Winter, 1978; Dierickx and Cool, 1989; Porter, 1991; Knott, Bryce and Posen, 2003). These are added back to determine the *rate of financial resource generation* (Equation 4-110).

$$\text{rate of resource generation} = \text{rate of value creation} * \text{share of value captured} \qquad \text{Eq 4-109}$$

$$\begin{aligned}\text{rate of financial resource generation} &= \text{rate of resource generation} \\ &+ \text{rate of amortisation of technological resources} \\ &+ \text{rate of depreciation of complementary assets} \\ &+ \text{rate of amortisation of content assets}\end{aligned} \qquad \text{Eq 4-110}$$

Growth process theories recognise that digital ventures need to access resources from the external environment such as investors and lenders (Garnsey, 1998; Santos and Eisenhardt, 2009; Gabrielsson and Gabrielsson, 2013; Garnsey, Lubik and Heffernan, 2015; Miozzo and DiVito, 2016). Ventures mobilise these resources by raising capital as equity and debt (Penrose, 1960; Garnsey, 1998; Heirman and Clarysse, 2004; Garnsey and Heffernan, 2005; Clarysse, Bruneel and Wright, 2011; Hesse and Sternberg, 2017). The *rate of equity raising* and *rate of debt raising* increase the *rate of capital raising*. The *rate of equity repurchasing* and the *rate of debt repayments* reduce the venture's capital raising (Equation 4-111). All variables measure the rate at which capital is raised and repaid in monetary amounts per period. The next subsubsection further specifies these.

$$\begin{aligned}\text{rate of capital raising} &= \text{rate of equity raising} - \text{rate of equity repurchasing} \\ &+ \text{rate of debt raising} - \text{rate of debt repayments}\end{aligned} \qquad \text{Eq 4-111}$$

Over time, the venture invests its financial resources into technological resources, complementary assets, and content assets. The *rate of investments* is the sum of these individual investment rates (Equation 4-112).

$$\begin{aligned}\text{rate of investments} &\\ &= \text{rate of investment in technological resources}\\ &+ \text{rate of investment in complementary assets}\\ &+ \text{rate of investment in content assets}\end{aligned} \qquad \text{Eq 4-112}$$

The technology development, firm management, and content creation subsystems specify these individual investment rates.

4.5.3.2. Equity and debt employed

The venture's balance sheet assets like its technology, complementary assets, and financial resources require funding and financing. The counterpart of the balance sheet assets is the debt and equity employed (Figure 4-40). Both types of capital are recognised in monetary amounts on the firm's balance sheet as liabilities and equity. They accumulate by raising new equity and debt. Repayments of debt and repurchases of equity lower the respective capital employed. These activities also affect the company's financial resources illustrated above (Garnsey, 1998; Garnsey, Dee and Ford, 2006; Stam and Garnsey, 2007; Gabrielsson and Gabrielsson, 2013; Garnsey, Lubik and Heffernan, 2015; Ingley, Khlif and Karoui, 2017). The capital employed affects the venture's ability to capture value because digital ventures may compensate their capital providers.

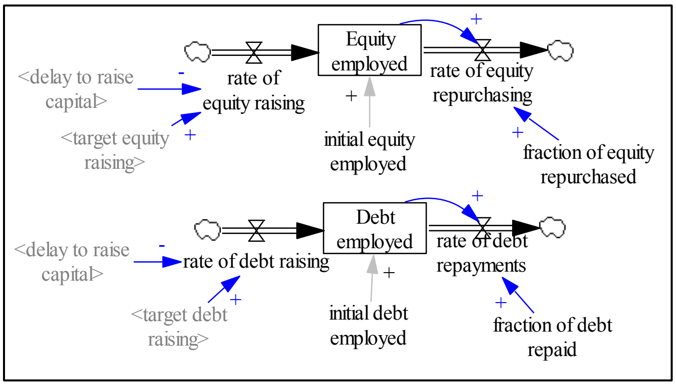


Figure 4-40: Equity and debt employed

The equity and debt employed by a digital venture result from the accumulation of raising and repaying each type of capital. The equity employed accumulates through the *rate of equity raising* and the *rate of equity repurchasing* (Equation 4-113). The debt employed accumulates through the *rate of debt raising* and the *rate of debt repayments* (Equation 4-114).

$$\begin{aligned}\text{Equity employed} &= \text{initial equity employed} \\ &+ \int (\text{rate of equity raising} - \text{rate of equity repurchasing})\end{aligned} \quad \text{Eq 4-113}$$

$$\begin{aligned}\text{Debt employed} &= \text{initial debt employed} \\ &+ \int (\text{rate of debt raising} - \text{rate of debt repayments})\end{aligned} \quad \text{Eq 4-114}$$

The *rate of equity raising* and *rate of debt raising* have been calculated in the same manner as the rates of hiring and investments into complementary assets. The model calculates them by achieving the *target equity raising* and the *target debt raising* over the *delay to raise capital* (Equation 4-115, 4-116). The *rate of debt repayment* and *rate of equity repurchase* have been calculated using the respective stock of equity and debt and the *fraction of debt repaid* and *fraction of equity repurchased* per year (Equation 4-117, 4-118).

$$\text{rate of equity raising} = \text{target equity raising}/\text{delay to raise capital} \quad \text{Eq 4-115}$$

$$\text{rate of debt raising} = \text{target debt raising}/\text{delay to raise capital} \quad \text{Eq 4-116}$$

$$\begin{aligned}\text{rate of equity repurchasing} \\ &= \text{Equity employed} * \text{fraction of equity repurchased}\end{aligned} \quad \text{Eq 4-117}$$

$$\text{rate of debt repayments} = \text{Debt employed} * \text{fraction of debt repaid} \quad \text{Eq 4-118}$$

Most digital ventures do not repurchase equity, and debt repayment depends on the agreements with their lenders (Mudambi and Treichel, 2005). Therefore, the fractions of repurchasing and repayments are inputs based on the firm's financial statements. The rates of debt and equity raising depend on the management's target and delay to raise capital. The target is discussed below. The delay is formalised in the same manner as the hiring and investment delay (see Appendix A).

4.5.3.3.   Liquidity adequacy and target equity and debt raising

Digital ventures may need to raise capital to finance their customer growth, user growth, technology improvement, and content creation plans. Companies use this capital to finance costs incurred before the expansions and improvements begin to pay off. The raising of this capital thereby has two crucial implications. Firstly, digital ventures typically raise capital before executing their expansion plans. Therefore, fundraising needs may delay hiring and investments into complementary assets (Garnsey, 1998; Hugo and Garnsey, 2005; Garnsey, Dee and Ford, 2006; Brown and Mawson, 2013; Miozzo and DiVito, 2016; Ingley, Khlif and Karoui, 2017). The model considers this delay through the liquidity adequacy. It reduces hiring and investment rates depending on the available financial resources and liquidity requirements. Secondly, depending on the venture's financial resources, a liquidity shortfall is created. The venture fills the shortfall by raising more equity and debt (Figure 4-41).

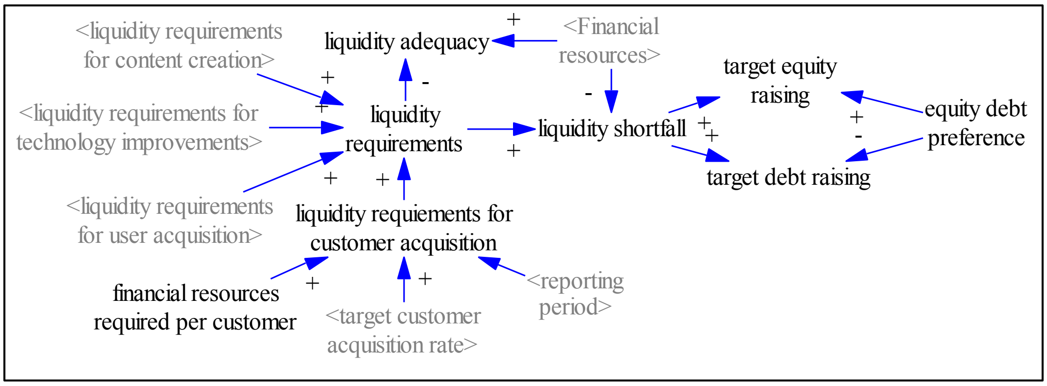


Figure 4-41: Liquidity adequacy, shortfall, and capital targets

The *liquidity adequacy* expresses the venture's *financial resources* as a fraction of the *liquidity requirements*. The model caps the adequacy at one (Equation 4-119). The venture's liquidity requirements have been split into the areas of expansion and improvement that might require financing. These are requirements for customer acquisition, user and premium user acquisition, technology improvements, and content creation (Equation 4-120). For example, the liquidity requirements for customer acquisition depend on the venture's *target customer acquisition rate*, the *reporting period* it raises funds for, and the *financial* *resources required per customer* (Equation 4-121)[21]. The acquisition rate expresses the rate at which the venture's employees need to acquire customers to achieve its growth goals. The human resource management section has covered it in detail. The reporting period has been set as one and the financial resources per customer acquisition are an input set through automatic model calibration.

$$\text{liquidity adequacy} = \text{MIN}(1, \text{XIDZ}(\text{Financial resources}, \text{liquidity requirements}, 1)) \quad \text{Eq 4-119}$$

$$\begin{aligned}\text{liquidity requirements} &= \text{liquidity requiements for customer acquisition} \\ &+ \text{liquidity requirements for technology improvements} \\ &+ \text{liquidity requirements for user acquisition} \\ &+ \text{liquidity requirements for content creation}\end{aligned} \quad \text{Eq 4-120}$$

$$\begin{aligned}\text{liquidity requirements for customer acquisition} &= \text{target customer acquisition rate} \\ &* \text{financial resources required per customer} \\ &* \text{reporting period}\end{aligned} \quad \text{Eq 4-121}$$

The venture needs to raise its *liquidity shortfall*. It is the difference between the *liquidity requirements* and *financial resources* unless resources already exceed the requirements (Equation 4-122). It can then decide if this capital will be raised in the form of equity or debt. The *equity debt preference* is used to model this choice. It reflects the fraction of capital the venture aims to raise in equity. Thus, its *target equity raising* is determined by the liquidity shortfall and its equity preference (Equation 4-123). The difference between one and the equity debt preference is the fraction of capital to be raised in the form of debt. Therefore, multiplying this difference with the liquidity shortfall generates the *target debt raising* (Equation 4-124).

$$\text{liquidity shortfall} = \text{MAX}(0, \text{liquidity requirements} - \text{Financial resources}) \quad \text{Eq 4-122}$$

$$\text{target equity raising} = \text{liquidity shortfall} * \text{equity debt preference} \quad \text{Eq 4-123}$$

[21] The liquidity requirements for users, technology improvements, and content are shown in Appendix A using the same structure and principles to avoid repetition in this chapter.

$$\text{target debt raising} = \text{liquidity shortfall} * (1 - \text{equity debt preference}) \quad \text{Eq 4-124}$$

The preference between equity and debt is a model input calculated by evaluating the fractions of capital raised by the venture each year.

4.5.4. Overview of subsystem

The outcomes of this subsystem are the venture's employees across its activities, its financial resources and types of capital employed, and its complementary assets (Table 4-5). This section has illustrated how these outcomes develop from their initial value based on the management's dominant logic and capabilities. Inputs from other subsystems are required to set goals in absolute values and determine the resources that need to be acquired to achieve them. For example, the targets for marketing and selling employees depend on a wide range of customer and user subsystem inputs. These determine acquisition targets and employees' ability to acquire customers and users. Similarly, the venture's targets for value delivering employees depend on inputs from the customer and user subsystem and the content creation subsystem (see Appendix A). The venture's target for technology developing employees depends on inputs from the technology development and value creation subsystems. The model also requires inputs from the value creation and capture subsystems for the accumulation of financial resources.

Table 4-5: Outputs and inputs of the firm managing subsystem

<table>
<tr><th colspan="2">Outputs</th></tr>
<tr><td colspan="2">• Marketing and selling employees, value delivering employees, technology developing employees, firm managing employees
• Complementary assets
• Financial resources, equity employed, debt employed</td></tr>
<tr><th>Inputs from other subsystems</th><th>Exogenous inputs</th></tr>
<tr><td>Value creation subsystem:
• Rate of value creation
• Technological quality, maximum technological quality, effect of investments technology improvements
Value capture subsystem:
• Share of value captured
Customer and user subsystem:
• Customer base, user base, premium user base
• Customer lifetime, user lifetime, premium user lifetime
• user to premium conversion rate, premium to user conversion rate
• Ability to acquire customers, ability to acquire users, ability to acquire premium users
• Rate of user acquisition per user, rate of user acquisition per customer, rate of premium user acquisition per user, rate of premium user acquisition per customer, rate of customer acquisition per user, rate of customer acquisition per customer
• Ability to service users, ability to service premium users, ability to create content
Content creation subsystem:
• Rate of investment in content assets, rate of amortisation of content assets
• Ability to create content, rate of external content creation
Technology development subsystem:
• Rate of investment in technological resources, rate of amortisation of technological resources
• Ability to develop technology ability to maintain technology</td>
<td>Dominant logic – Targets and limits:
• Target customer growth, target user growth, target premium user growth, target technology improvement, target content library growth
• MS employee cap, VD employee cap, TD employee cap, FM employee cap
Dominant logic – Human resource management:
• Initial marketing and selling employees, initial value delivering employees, initial technology development employees, initial firm managing employees
• Employee turnover rate
Dominant logic – Asset requirements:
• Complementary assets required per employee
• Financial resources required per customer, financial resources required per user, financial resources required per technology improvement, financial resources required per content item
• Equity debt preference
• Fraction of equity repurchased, fraction of debt repaid
Capability development:
• Initial firm management competence
• FM years of improvement
• New FM employee competence
Business model design:
• Effect of competence on ability to manage employees
Accounting measures:
• Initial financial resources, initial complementary assets, initial equity employed, initial debt employed
• Lifetime of complementary assets</td></tr>
</table>

External inputs to the firm managing subsystem relate to managerial targets and limits that express the venture's dominant logic during a growth state. The subsystem also requires inputs for initial employee and capital stocks, turnover rates, and complementary asset requirements. The analyst sets these based on information contained in annual reports and financial statements. The analyst also needs to set capability development variables using the same procedures as for other capabilities (see Appendices A and C). The effect size of the capability and funding requirements are set through automatic model calibration. The lifetime of complementary assets is directly imported from financial statements.

Chapter 5: Case simulation and model validation

The previous two chapters conceptualised and formalised a System Dynamics model that reveals the processes affecting digital ventures' ability to create value and capture a share of that value. The two chapters have integrated growth paths theory and dynamic states theory, contextualised the theories for digital ventures, and proposed a formal simulation model. This simulation model requires validation to establish the level of confidence in the model's approximations of company developments. Thereby, this chapter also establishes confidence in the ability of the proposed mechanisms to account for the dynamic changes in performance outcomes. This chapter simulates the model for the four case companies identified through the rigorous and extensive sampling process described in the methodology chapter (Subsubsection 2.4.1.1). The methodology also describes the process of setting up the model for each of the four case companies (Subsubsection 2.4.1.2). The complete model is run for each company. However, the presentation of the model's inputs and outputs is split based on the subsystems presented in the model formalisation chapter (Chapter 4). The presentation works backwards from the firm management over the technology developing and user/customer subsystems to the performance outcome subsystems. This structure allows for illustrating how the outputs from the former parts of the model serve as inputs to the latter parts. Each figure illustrates the subsystem's outcomes for one case company. To establish confidence in the model, figures include the outcomes calculated by the model (blue lines) and the company's actual historical data (red lines).

5.1. Firm managing subsystem

This section assesses the model's ability to approximate the outcomes of the firm managing subsystem. The subsystem depends on exogenous inputs regarding the management's dominant logic, capability development, business model design, and accounting measures (Table 4-5). It uses these inputs and those from other subsystems to determine the venture's human resources and capital assets. These variables are inputs to the activities of ventures to market to and service customers and users and develop its technology. The variables are also cost drivers in the value capture subsystem.

5.1.1. Alpha

Alpha is a UK-based company that provides communication software integrating into customer relationship management and human resource management platforms. The software is a cloud-based solution using a SaaS business model. Alpha's customers use the product to improve the productivity of their marketing, sales, customer service, and human resource departments. Data for Alpha is available for six years, during which time the company develops through three different growth states. For the first two years and a quarter (t=2.25), the venture aims to grow its customer base by 161% per year (Table 5-1). Afterwards, the venture changes its dominant logic. It reduces its customer growth goal to 20% and holds its marketing and selling employees constant at 7.25 indexed employees. All other employee numbers remain uncapped. During those first two growth states, Alpha's development employees integrate its software into additional platforms. While this increases Alpha's addressable market, it does not improve its product quality for existing customers. This changes when Alpha enters its third growth state after three and a half years of simulation (t=3.5). In this final growth state, the venture also targets technology improvements of 20% per year, reflecting major improvements.

The firm managing subsystem also requires inputs regarding the management's capability development and capital assets. The venture has an established management team and hires additional experienced managers. Therefore, the initial competence levels of the firm and new employees are set respectively at 0.5 and 0.3 on the capability maturity scale (see Appendix C). Employees take about two years to develop full proficiency. This training time has been set after reviewing the other case companies. A longer period has been set to reflect that the venture is less mature and has less developed training programmes than the other companies. The Vensim software estimated the impact of employee competence on hard variables. The software estimates that each fully equipped and capable indexed firm managing employee can manage about 26 indexed operational employees. The venture needs to equip its employee with sufficient complementary assets and maintain sufficient liquidity. The venture requires about 0.7% of initial total assets per indexed employee in complementary assets. The software estimates that the venture raises about 24% of initial total assets for each indexed customer it plans to acquire. It also raises 67% of initial total assets for each indexed technology improvement it plans to achieve. Moreover, an employee turnover rate of 30% has been set to reflect high employee turnover in Alpha. Alpha does not employ a content-based business model or distinguish between users and customers. Therefore, targets regarding users and content (see Appendix D) are not relevant for the venture and are therefore set to zero.

Table 5-1: Firm management inputs for Alpha[22]

<table>
<tr><th colspan="2">Dominant logic – targets and HR</th><th colspan="2">time: 0 - 2.25</th><th>t: 2.25 - 3.5</th><th colspan="2">time: 3.5 - 6</th></tr>
<tr><td colspan="2">Target customer growth</td><td colspan="2">161%</td><td colspan="3">20%</td></tr>
<tr><td colspan="2">Target user growth</td><td colspan="5">0%</td></tr>
<tr><td colspan="2">Target technology improvement</td><td colspan="3">0%</td><td colspan="2">20%</td></tr>
<tr><td colspan="2">Marketing and selling (MS) employee cap</td><td colspan="2">-1</td><td colspan="3">7.25</td></tr>
<tr><td colspan="2">Value delivering (VD) employee cap</td><td colspan="5">-1</td></tr>
<tr><td colspan="2">Tech. developing (TD) employee cap</td><td colspan="5">-1</td></tr>
<tr><td colspan="2">Firm managing (FM) employee cap</td><td colspan="5">-1</td></tr>
<tr><th colspan="3">Capabilities - firm managing</th><th colspan="4">Capital asset requirements</th></tr>
<tr><td>initial firm managing competence</td><td colspan="2">0.5</td><td colspan="3">complementary assets per emp.</td><td>0.7%</td></tr>
<tr><td>firm managing years of improvement</td><td colspan="2">2</td><td colspan="3">liquidity goal per customer</td><td>24%</td></tr>
<tr><td>new FM employee competence</td><td colspan="2">0.3</td><td colspan="3">liquidity goal per user</td><td>0%</td></tr>
<tr><td>Employee turnover rate</td><td colspan="2">30%</td><td colspan="3">liquidity goal per tech improvement</td><td>67%</td></tr>
<tr><td colspan="6">effect of competence on ability to manage the firm</td><td>26</td></tr>
</table>

With a dominant logic focussed on customer growth in its first growth state, theory suggests that Alpha will hire more marketing and selling employees to achieve its growth targets. It will also hire value delivering employees to service the acquired customers. The venture's marketing and selling employees should remain at their capped value in the second and third growth state. However, these marketing and selling employees will still acquire additional customers that the venture needs to service. Therefore, value delivering employees may continue to increase. Moreover, the venture's technology developing employees should only

[22] All simulations have a starting time of zero rather than a specific year in order to obscure company identities. If input values have been altered with growth states, these states are presented with this relative time point in the tables. For example, the column titled "time: 0 – 2.25" includes values set for the company between the start of the simulation and time point 2.25. If values span across growth states, the variable's row also spans across growth states in the table. Initial values and constants are presented without time indications. This applies, for example, to the capabilities and asset requirements in Table 5-1. Please also note that values are rounded.

rise significantly when Alpha decides to pursue new development goals in its third growth state. Due to these additional hires throughout its activities, more managing employees will be required to manage the firm's human resources. The venture also needs additional complementary assets to equip employees appropriately. The venture needs to raise additional capital to finance those assets and maintain sufficient liquidity because it loses resources throughout the years (see value capture subsystem).

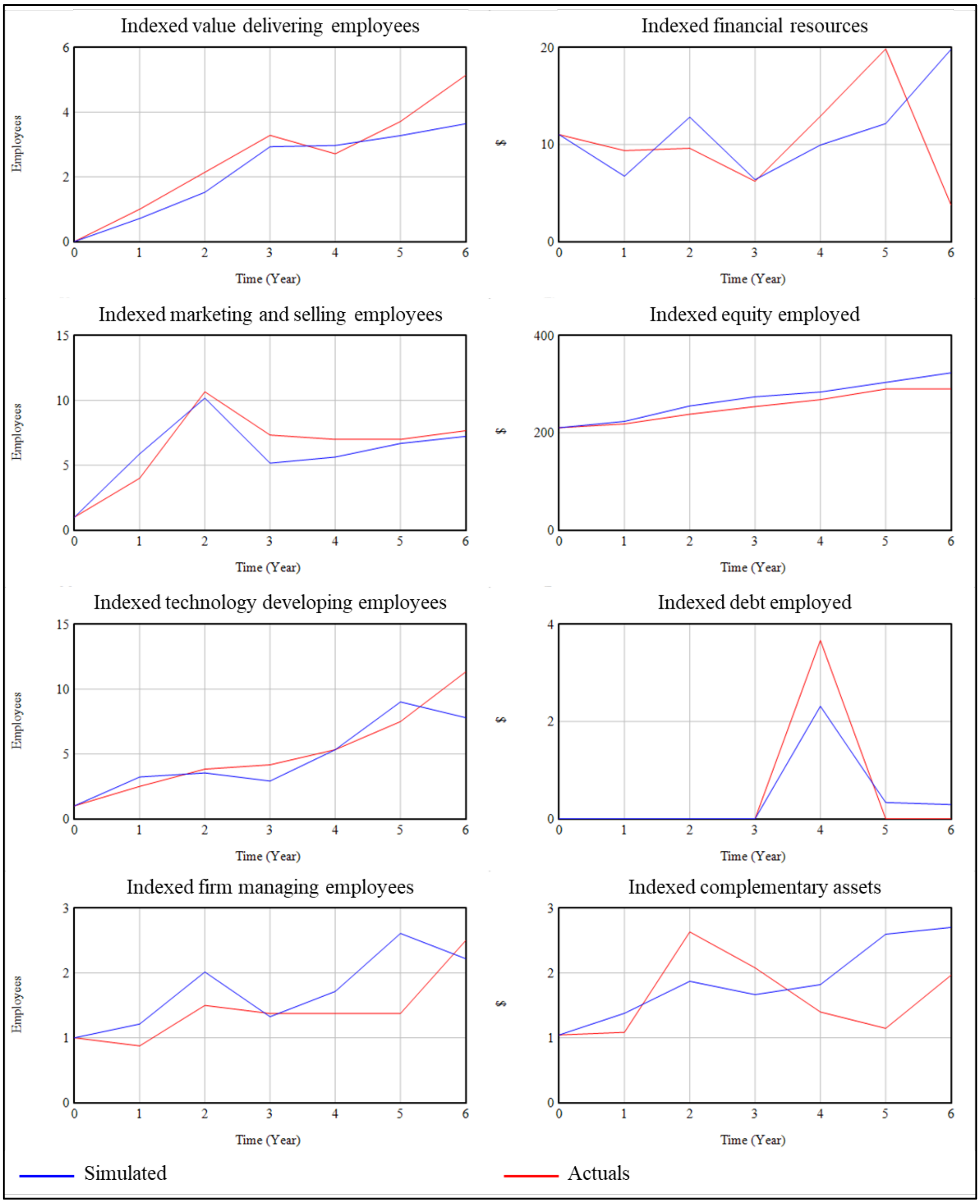


Figure 5-1: Firm managing outputs for Alpha[23]

The model and company data match theoretical expectations in the different growth states (Figure 5-1). The model and company history show that technology development employees increase substantially to achieve the target improvements in the venture's product in the third growth state. The venture's marketing and selling employees peak during the second year to achieve its customer growth goals. The venture's value delivering employees increase throughout the years

[23] The blue lines visualise the model's calculations and the red lines visualise the case companies' actual historical data. The same applies to all graphs and figures in this chapter.

due to its increasing customer base (see customer and user subsystem). The model also accounts for the rise in the venture's firm managing employees. While the model slightly overestimates firm managing employees, it underestimated value delivering employees. Besides this minor mismatch, the model's approximations of complementary assets increase with the historical data but remain stable when complementary assets fall for the case company. This might be due to the accounting treatment of complementary assets. Alpha may depreciate complementary assets even though it is still using the equipment. In the model, it replaces depreciated equipment through new investments that might not occur in reality. The equity and debt employed fit well to the historical data. However, the model cannot account for the volatility of historical financial resources. This mismatch might occur because the theory and thus the model do not account for all differences between profit as an amount of value captured and cash flow. Cash flow might also be affected by, for example, customers delaying payment or prepaying expenses. These additional processes lead to timing differences in capturing value and accumulating the captured value as financial resources, which the model and theory do not consider.

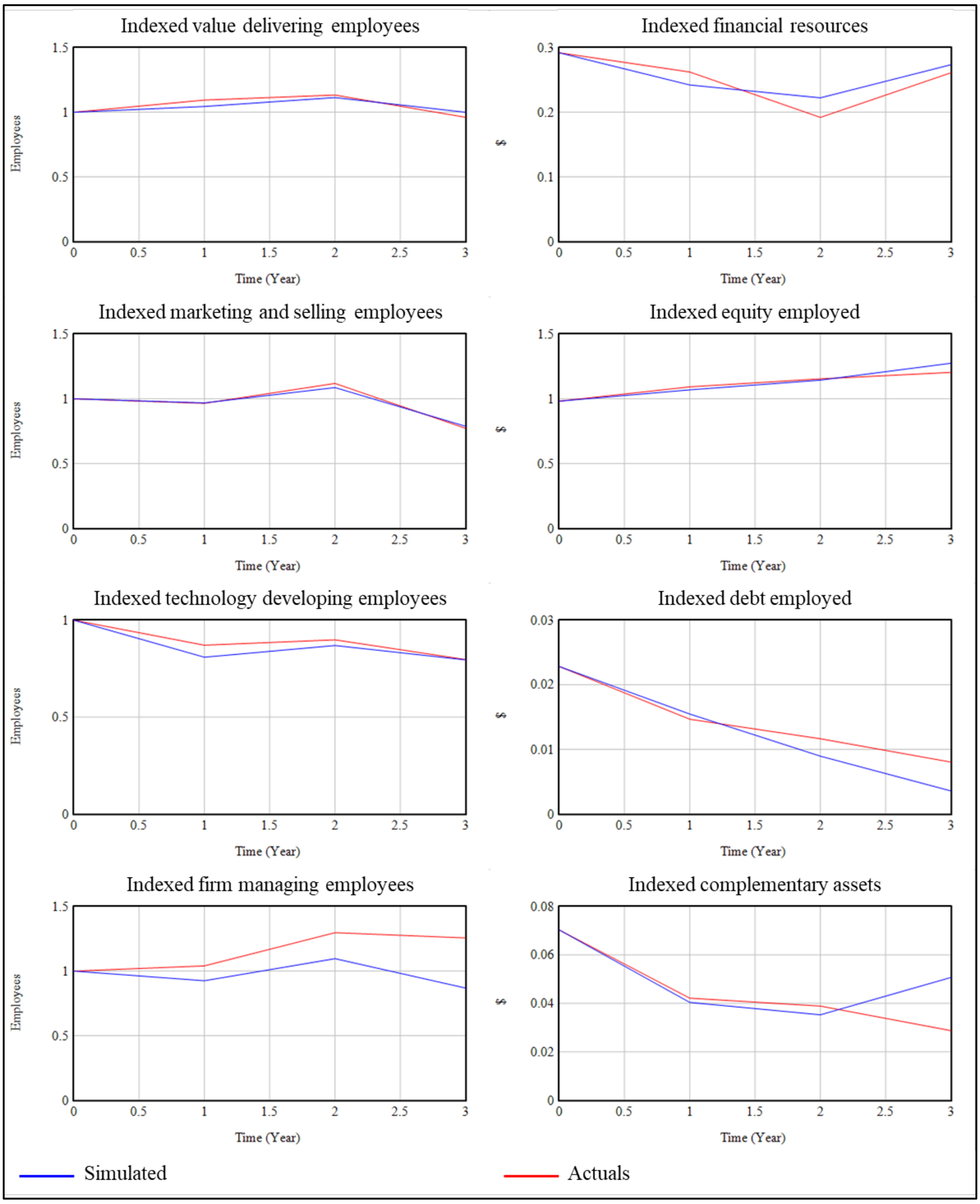
5.1.2. Beta

Beta is a US-based company that offers communication software for businesses and their teams. Beta claims that its SaaS product helps its customers to improve productivity and reduce costs. Three years of data are available for Beta, during which the company develops through two growth states. In both growth states, Beta pursues major improvements to its technology. Thus, a technology improvement goal of 20% has been set (Table 5-2). During the first growth state, lasting for two and a half years (t=2.5), the company aims to grow its customer base by 7% per year. During the second growth state, lasting until the end of the third year, the company restructures. Beta reduces its employees across all activities to between 0.8 and 1.25 indexed employees. The employee turnover rate is set to 20%. In addition, the venture requires 1.3% of initial total assets in complementary assets per indexed employee. The venture raises 154% of initial total assets to finance one indexed improvement in its technology and 7.1% of initial total assets to finance its the acquisition of one indexed customer. Due to the higher maturity of Beta as a company compared to Alpha, initial capability levels of 0.7 have been selected to reflect the company's processes. New employees lack integration into processes. Therefore, a capability level of 0.3 has been set for new employees. The venture states that it takes about nine to twelve months to train new employees. Therefore, the training time is set to one year. Lastly, the Vensim software has set the variables converting employees' competence. It estimates that each indexed firm managing employees can manage six indexed employees at fully developed capabilities and sufficient equipment.

Table 5-2: Firm management inputs for Beta

<table>
<tr><th colspan="2">Dominant logic – targets and HR</th><th colspan="2">time: 0 - 2.5</th><th>time: 2.5 - 3</th></tr>
<tr><td colspan="2">Target customer growth</td><td colspan="2">7%</td><td>0%</td></tr>
<tr><td colspan="2">Target user growth</td><td colspan="3">0%</td></tr>
<tr><td colspan="2">Target technology improvement</td><td colspan="3">20%</td></tr>
<tr><td colspan="2">Marketing and selling (MS) employee cap</td><td colspan="2">-1</td><td>0.8</td></tr>
<tr><td colspan="2">Value delivering (VD) employee cap</td><td colspan="2">-1</td><td>1</td></tr>
<tr><td colspan="2">Tech. developing (TD) employee cap</td><td colspan="2">-1</td><td>0.8</td></tr>
<tr><td colspan="2">Firm managing (FM) employee cap</td><td colspan="2">-1</td><td>1.25</td></tr>
<tr><th colspan="2">Capabilities - firm managing</th><th colspan="3">Capital asset requirements</th></tr>
<tr><td>initial firm managing competence</td><td>0.7</td><td colspan="2">complementary assets per emp.</td><td>1.3%</td></tr>
<tr><td>firm managing years of improvement</td><td>1</td><td colspan="2">liquidity goal per customer</td><td>7.1%</td></tr>
<tr><td>new FM employee competence</td><td>0.3</td><td colspan="2">liquidity goal per user</td><td>0%</td></tr>
<tr><td>Employee turnover rate</td><td>20%</td><td colspan="2">liquidity goal per tech. improvem.</td><td>154%</td></tr>
<tr><td colspan="4">effect of competence on ability to manage the firm</td><td>6</td></tr>
</table>

Theory suggests that the venture increases its marketing and value delivering employees to increase its customer base during the first growth state. In addition, the venture needs to hire additional managers to supervise the larger number of employees, acquire additional complementary assets, and raise more capital to maintain its liquidity targets. During the last growth state, theory suggests a decrease in all these variables to account for its restructuring.



<u>Figure 5-2: Firm managing outputs for Beta</u>

The model and historical data support the expectations from theory during the two growth states (Figure 5-2). As expected, its marketing, value delivering, and firm managing employees reach a high at the end of the second year, just before the end of its first growth state. The venture lays off technology developing employees because fewer employees can achieve the same output due to learning effects. The model can also approximate the venture's financial resources, equity, debt, and complementary assets well. As for Alpha, the model smooths out financial resources and does not capture their complete volatility. Moreover, the venture overestimates complementary assets in the final year. This mismatch can be explained by a sale of complementary assets that the model does not consider.

5.1.1. Gamma

Gamma provides a platform connecting advertisers and online video publishers. While advertisers use Gamma's platform to distribute video adverts, publishers can use the platform to monetise their video content. While the company is based in the United States, it expanded internationally two years before the simulation period. Three years of data are available for Gamma, during which the company develops through two different growth states. Initially, Gamma plans to increase the number of advertisers (customers) on its platform by 33% per year (Table 5-3). After two years and three quarters (t=2.75), the company abandons its customer growth goal and restructures. It introduces caps on its employee numbers of between 0.6 and 1.6 indexed employees. This state lasts until the end of the third year. No additional years of data are available because the company has been taken over. The turnover rate has been set to 30% to reflect the high turnover that the company notices in its international subsidiaries. Moreover, the company pursues minor improvements to its technology throughout the years of simulation.

The company needs to maintain about 0.9% of initial total assets in complementary assets per indexed employee. It raises 32% of initial total assets to finance acquiring one indexed customer. Due to a similar maturity of Gamma, Beta's initial capability levels, improvement rates, and new employees capabilities are used. The Vensim software estimated the effect sizes that transform the management capabilities from a soft scale to a hard impact on the system. Each fully equipped and capable indexed employee can manage nearly eight indexed operating employees.

Table 5-3: Firm management inputs for Gamma

Dominant logic – targets and HR	**time: 0 - 2.75**	**time: 2.75 - 3**
Target customer growth	33%	0%
Target user growth	0%	
Target technology improvement	10%	
Marketing and selling (MS) employee cap	-1	0.95
Value delivering (VD) employee cap	-1	1
Tech. developing (TD) employee cap	-1	1.6
Firm managing (FM) employee cap	-1	1.25

Capabilities - firm managing		**Capital asset requirements**	
initial firm managing competence	0.7	complementary assets per emp.	0.9%
firm managing years of improvement	1	liquidity goal per customer	32%
new FM employee competence	0.3	liquidity goal per user	0%
Employee turnover rate	30%	liquidity goal per tech. improvem.	0%
effect of competence on ability to manage the firm			7.7

Due to Gamma's customer growth goal in the first growth state, it should be expected that the venture increases its marketing and selling employees. In addition, its value delivering employees should increase with its customer base. Lastly, its technology developing employees should increase slightly to maintain the continuously developing technology stock. Theory suggests that the venture also needs to increase its firm managing employees, complementary assets, and capital employed. These are required to manage, equip, and finance the increase in employees.

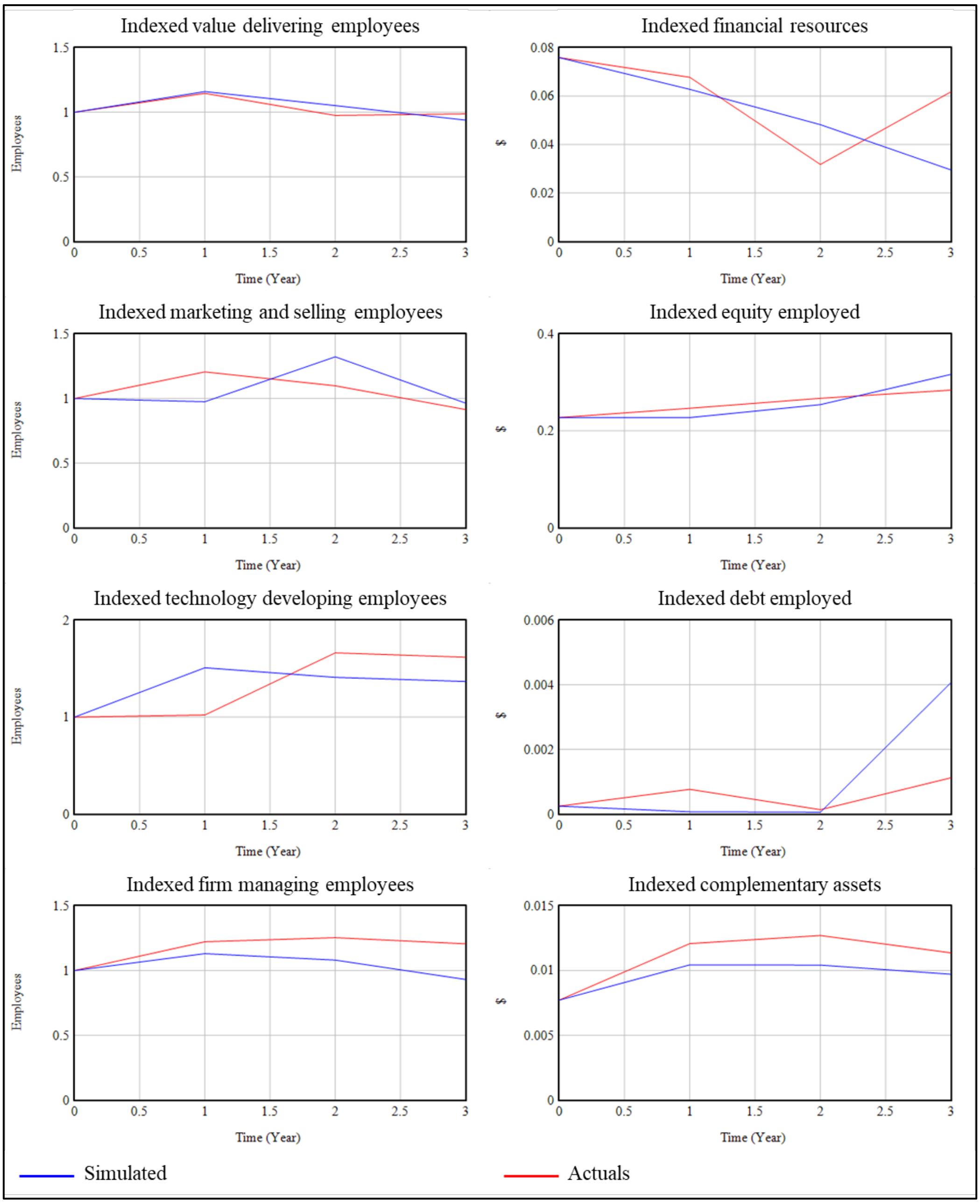


Figure 5-3: Firm managing outputs for Gamma

The theory, model, and actual data coincide with most of these expectations (Figure 5-3). The firm's marketing, value delivering, and technology developing employees increase in the first two years and fall with the restructuring in the final year. Its firm managing employees and complementary assets follow the patterns of operating employees. Moreover, the model tracks well the equity and debt employed by the venture. However, there are differences regarding the timing of increases and decreases of the venture's employees. For example, in the model, marketing and selling employees increase until the growth state transition.

The historical data shows that marketing employees increase for only one year and start falling before the transition. These differences indicate a mismatch between quantitative and qualitative company data. The management has not officially changed strategy and restructured during the second year of simulation. However, its marketing and selling employees are already falling. Gamma also reduces its value delivering employees to the cap introduced as part of the restructuring in the following year. Thus, it seems that the management is restructuring earlier than it is communicating. This leads to tracking errors in other types of employees and complementary assets that build on the employee numbers. A final difference for Gamma's firm managing outcomes concerns its financial resources. While historical data shows an increase in financial resources with the restructuring, the model's financial resources continue to fall. These resources accumulate through capturing value and raising capital. Because the model approximates the capital well, it is an error carried forwards from capturing value (see value capture subsystem below).

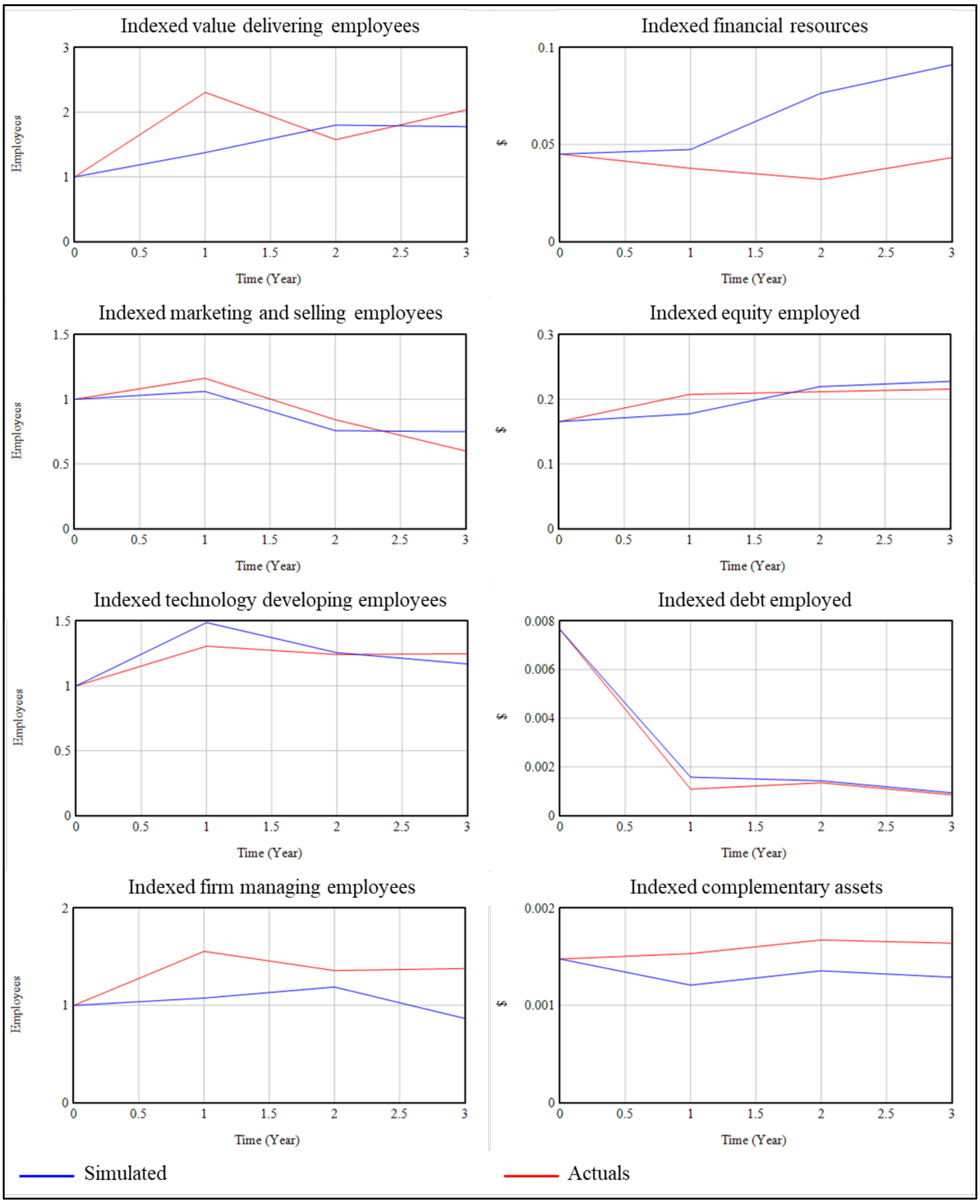
5.1.2. Delta

Delta is a European company operating a marketplace for travel bookings. While the company provides an advertising platform for travel providers, users can find and compare travel options on the platform. Three years of data are available for the company, during which it develops through two growth states (Table 5-4). Throughout its development, Delta aims to increase its customers (travel providers) by 48% per year. Like Gamma, Delta develops through a period of growth until one year and three quarters (t=1.75). Delta aims to increase its user base (travellers) during this first growth state by 35% per year. It then restructures and reduces its employee numbers to between 0.75 and 1.8 indexed employees. Throughout these years, the company improves the user experience on its website. However, most of its development focuses on optimising the back end of its platform. Therefore, a target technology improvement goal of 10%, reflecting minor improvements, has been set. The company is proud of its entrepreneurial culture, including promoting junior staff and its ability to train them. However, Delta also outlines the risk of this culture, including promoting people without the necessary skills and experience. To reflect Delta's entrepreneurial culture, the capability level of new employees has been set to 0.1, while its training time has been set to half a year. While new employee competence is lower than for other case companies, the training time is quicker too. The lower turnover rate of 20% has been set to reflect that the company does not report adverse employee relationships. The Vensim software has set the venture's ability to manage employees to eight indexed operational employees. The venture requires about 0.2% of initial total asset in complementary assets per indexed employee. It raises capital to finance customer acquisition and user acquisition targets.

Table 5-4: Firm management inputs for Delta

<table>
<tr><th colspan="2">Dominant logic – targets and HR</th><th colspan="2">time: 0 - 1.75</th><th>time: 1.75 - 3</th></tr>
<tr><td colspan="2">Target customer growth</td><td colspan="3">48%</td></tr>
<tr><td colspan="2">Target user growth</td><td colspan="2">35%</td><td>0%</td></tr>
<tr><td colspan="2">Target technology improvement</td><td colspan="3">10%</td></tr>
<tr><td colspan="2">Marketing and selling (MS) employee cap</td><td colspan="2">-1</td><td>0.75</td></tr>
<tr><td colspan="2">Value delivering (VD) employee cap</td><td colspan="2">-1</td><td>1.8</td></tr>
<tr><td colspan="2">Tech. developing (TD) employee cap</td><td colspan="2">-1</td><td>1.25</td></tr>
<tr><td colspan="2">Firm managing (FM) employee cap</td><td colspan="2">-1</td><td>1.4</td></tr>
<tr><th colspan="2">Capabilities - firm managing</th><th colspan="3">Capital asset requirements</th></tr>
<tr><td>initial firm managing competence</td><td>0.7</td><td colspan="2">complementary assets per emp.</td><td>0.2%</td></tr>
<tr><td>firm managing years of improvement</td><td>0.5</td><td colspan="2">liquidity goal per customer</td><td>30%</td></tr>
<tr><td>new FM employee competence</td><td>0.1</td><td colspan="2">liquidity goal per user</td><td>5.4%</td></tr>
<tr><td>Employee turnover rate</td><td>20%</td><td colspan="2">liquidity goal per tech. improvem.</td><td>0%</td></tr>
<tr><td colspan="4">effect of competence on ability to manage the firm</td><td>8</td></tr>
</table>

Like the theoretical expectations for Gamma, Delta should exhibit constant or increasing technology developing employees to achieve its minor improvements. Its marketing and selling employees should increase during the first growth state to achieve customer and user growth targets. With the development in marketing employees, the venture's firm managing employees should increase to manage the additional employees. These additional employees also require equipment through complementary assets, and capital should be raised to finance the growth and technology improvements.



<u>Figure 5-4: Firm managing outputs for Delta</u>

The model and historical data support these theoretical expectations (Figure 5-4). Technology developing employees increase during the first year, indicating that additional employees were required to achieve the technology improvement goals and maintain the existing technology. The venture's marketing and value delivering employees peak during the first growth state and fall afterwards. With the increasing employee numbers, firm managing employees increase during the first growth state and fall with the restructuring. The model can approximate some of these developments. It reflects well the increase in firm managing employees. Moreover, it can approximate well the fall of marketing and selling employees. However, the model's approximations of value delivering and management employees is off. The model does not reflect the peak in value delivering employees after one year because its user base does not capture a peak in users (see customer and user subsystem). This underestimation also causes firm managing employees to remain below the actual data. The venture also raises capital to finance its growth and improvement goals. These are well approximated in the model. However, the model's approximations of complementary assets and financial resources are off. These are errors carried forward from the mismatch for value delivering and firm managing employees. With too low employee stocks, the model assumes that the venture also requires fewer complementary assets. Because the venture invests less money into complementary assets, its financial resources are inflated. Moreover, the model overestimates revenue (see value capture subsystem), increasing financial resources further.

5.2. Technology developing subsystem

This section illustrates the model's ability to approximate the development of a venture's technological resources. Each case company's inputs are illustrated (see Table 4-3). The subsystem also depends on the technology developing employees. The section then compares the technological resources calculated in the model to the indexed assets reported on a venture's balance sheets.

5.2.1. Alpha

Parameters regarding capabilities need to be set to simulate the technology developing subsystem. The same capability inputs as for firm managing activities have been set for Alpha. Through automatic model calibration, the Vensim software set the effects of employee competence on developing and maintaining the venture's technology. At fully developed capabilities, each indexed employee can create 13% of initial total assets of new software per year and maintain 69% of the venture's initial technological quality.

Table 5-5: Technology developing inputs for Alpha

Capability development			
initial technology developing competence	0.5	effect of competence on ability to develop technology	13%
TD years of improvement	2	effect of competence on ability to maintain technology	69%
new TD employee competence	0.3		

Alpha does not focus on developing new technology in its first two growth states. Instead, it maintains its existing technology and integrates it into additional platforms. Therefore, theory suggests that no new development should take place during the first two growth states. Due to amortisation, technological resources should decrease during this time. Technological resources should only increase with the third growth state when the venture hires additional employees to develop its technology and improve its quality.

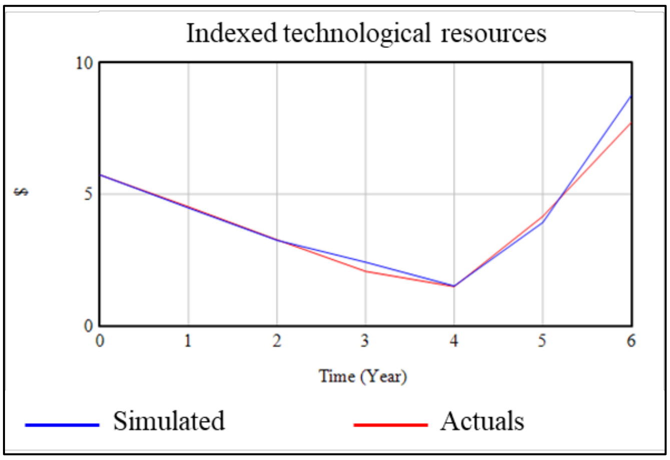


Figure 5-5: Technological resources of Alpha

The developments suggested by theory in the growth states are reflected in the venture's technological resources over time and approximated well by the model (Figure 5-5). The model calculates that the venture's technological resources decrease until the fourth year of simulation. Thus, during the first four years, the amortisation of technological assets is larger than the development of new technology. Afterwards, the technological resources increase until the end of the simulation as Alpha improves its product. In reality, the venture improves the reliability of its software by reworking its backend and launching a series of new features for its existing customers, such as a mobile app.

5.2.2. Beta

The capability inputs described for firm managing capabilities have also been used for Beta's other activities. In addition, one indexed employee, fully trained and equipped, can maintain the venture's initial technology about twice and develop new technology worth 5% of initial total assets per year (Table 5-6).

Table 5-6: Technology developing inputs for Beta

Capability development			
initial technology developing competence	0.7	effect of competence on ability to develop technology	5%
TD years of improvement	1	effect of competence on ability to maintain technology	212%
new TD employee competence	0.3		

Beta's technological resources should increase as the company plans major feature releases to improve its technology. However, Beta's technological resources also amortise over time. The overall development of resources should thus depend on the balance of new developments and amortisation. Particularly the layoff in its second growth state may lead to falls in technological resources. In that growth state, employee levels may have fallen below the threshold required to maintain the technology adequately and develop new features.

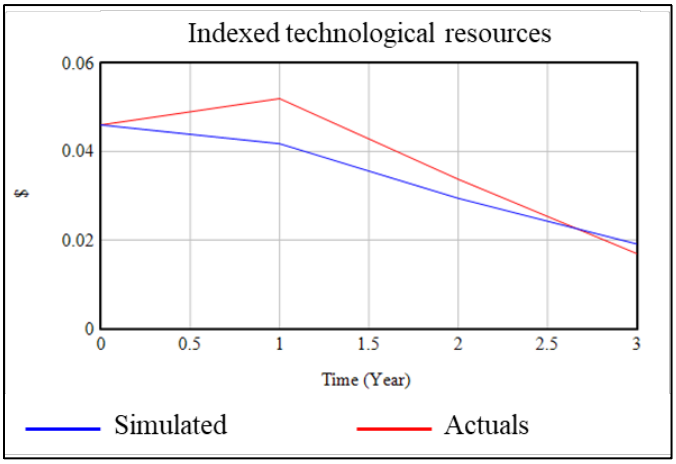


Figure 5-6: Technological resources of Beta

The model and historical case data support the theoretical arguments (Figure 5-6). While the venture was able to develop some new technology in its first year, technological resources decreased in the last two years. The model can approximate well the decrease in technological resources. It captures a small decrease in the first year, where the actual data increases. This development indicates that technological improvements take place particularly in the first year.

5.2.3. Gamma

Gamma's firm managing capability inputs have also been used for its other activities. In addition, one fully trained and equipped indexed employee can maintain 121% of the venture's initial technology and develop new technology worth 34% of initial total assets per year (Table 5-7).

Table 5-7: Technology developing inputs for Gamma

Capability development			
initial technology developing competence	0.7	effect of competence on ability to develop technology	34%
TD years of improvement	1	effect of competence on ability to maintain technology	121%
new TD employee competence	0.3		

Because the venture pursues minor improvements in its technology and is very capable of maintaining it, technological resources may increase if new developments outweigh amortisation. With the restructuring and lower technology developing employees, the rise in technological resources should slow down or even fall during the final growth state and year.

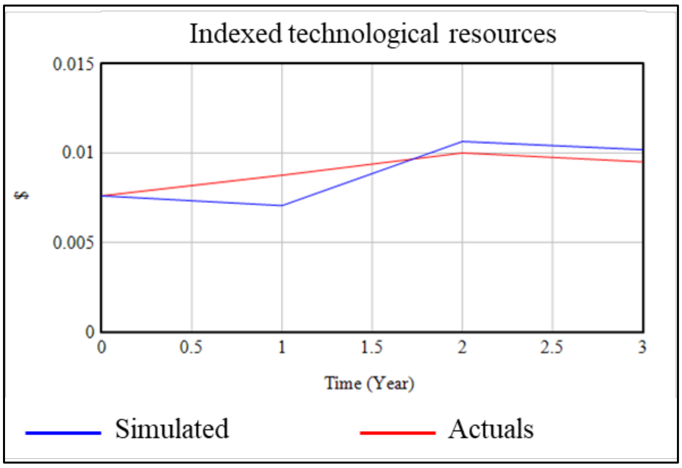


Figure 5-7: Technological resources of Gamma

The model and data support the theory (Figure 5-7). The historical case data shows that the venture can increase its technological resources over the first two years of simulation and slightly decrease in the third year of simulations. These changes align with its growth states, and the model approximates them well with only a minor mismatch in the first year.

5.2.4. Delta

The firm managing capability inputs have also been used for Delta's other activities. The Vensim software has set the impact of the capabilities on the hard variables of the system with one fully trained and equipped indexed employee being able to maintain 172% of the venture's initial technology and develop new technology worth 1.5% of initial total assets per year (Table 5-8).

Table 5-8: Technology developing inputs for Delta

Capability development			
initial technology developing competence	0.7	effect of competence on ability to develop technology	1.5%
TD years of improvement	0.5	effect of competence on ability to maintain technology	172%
new TD employee competence	0.1		

Because technology development was a minor priority for Delta, theory suggests that the venture's technology developing resources increase if they are in excess of amortisation.

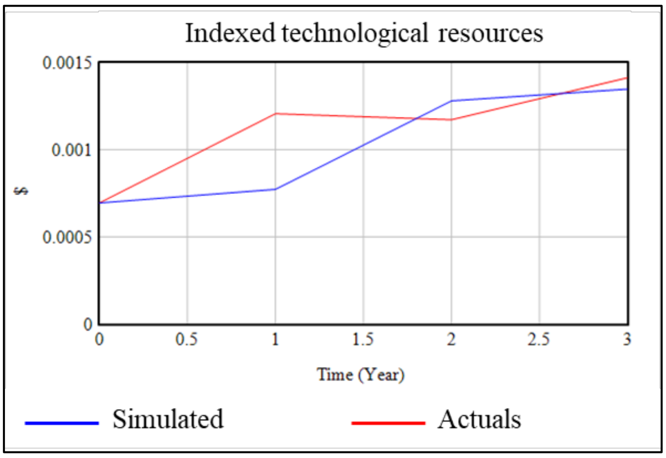


Figure 5-8: Technological resources of Delta

The model and data support this theoretical claim (Figure 5-8). Technological resources increase during the first year where the venture hires additional employees and remain about constant afterwards with a slight increase in the final year. The model timing is slightly off, reflecting the increase in technological resources in the second rather than first year.

5.3. Customer and user subsystem

This section assesses the model's ability to approximate the venture's customer base, user base, and premium user base. These developments depend on the exogenous inputs for the customer and user subsystem particularly regarding customer and user behaviour and employee capabilities. They also utilise inputs from the firm managing, value creation, and value capture subsystems (see Table 4-4).

5.3.1. Alpha

Because Alpha only provides value to customers, the customer base has an initial value of one (Table 5-9). Many variables related to users and premiums users, their lifetimes, acquisition through marketing and word-of-mouth, and servicing are zero. The same values as for Alpha's technology developing capabilities have been used. Through calibration of the model, a standard customer lifetime of eight years has been set. Each indexed employee can acquire 1.5 indexed customers per year and service seven indexed customers at fully developed capabilities.

__Table 5-9: Customer and user subsystem inputs for Alpha__

User and customer behaviour			
initial customer base	1	rate of customer acquisition per customer	0
initial user base	0	rate of customer acquisition per user	0
initial premium user base	0	rate of user acquisition per customer	0
user to premium conversion rate	0	rate of user acquisition per user	0
premium to user conversion rate	0	rate of premium user acquisition per cust.	0
standard customer lifetime	8	rate of premium user acquisition per user	0
standard user lifetime	0		
Capability development			
initial marketing selling competence	0.5	initial value delivering competence	0.5
MD years of improvement	2	VD years of improvement	2
new MS employee competence	0.3	new VD employee competence	0.3
effect of competence on ability to acquire customers			1.5
effect of competence on ability to acquire users			0
effect of competence on ability to acquire premium users			0
effect of competence on ability to service customers			7
effect of competence on ability to service users			0

Alpha focussed on growing its customer base during the first growth state. Thus, the venture increases its value delivering and marketing and selling employees in the first two years. With higher inputs to the venture's activities, theory suggests that the venture's customer base increases during that time. Firstly, more marketing and selling employees increase the rate at which Alpha acquired customers. Secondly, additional value delivering employees increase the venture's service capacity, increasing the customer lifetime due to better service. However, theory also suggests that quick hiring should lead to a drop in the venture's productivity. Therefore, the customer base should not rise as quickly as the venture's employees. All else being equal, customer growth in the last two growth states should be lower than during the first due to fewer marketing employees. The acquisition of new customers should accelerate due to improving capabilities of those employees. However, an increase in competition (see value capture subsystem) negatively affects customer acquisition and lifetime.

Figure 5-9: Customer subsystem outputs for Alpha

Historical data from Alpha and the model reflect the theory (Figure 5-9). During the first growth state, Alpha's customer base increases nearly seven-fold from its initial index of one until the end of the second year. As expected, this is a lower increase than the firm's marketing and selling employees, which increase ten-fold during the same period (Figure 5-1). The model approximations reflect the exponential increase in the customer base. However, the model underestimates this increase. It then carries this error forward and continues to underestimate the customer base during the second and third growth states.

5.3.2. Beta

Like Alpha, Beta does not distinguish between customers, users, and premium users. Therefore, only the customer stock is used in the model. Variables related to users and premium users have been set as zero (Table 5-10). Moreover, variables related to word-of-mouth marketing have also been set as zero as the company claims to acquire its customers through its marketing and selling employees. The Vensim software estimates a standard customer lifetime of about seven years. Capability levels for Beta have been set in line with those for its other activities. Lastly, one indexed employee with fully developed capabilities can acquire 1 and service 1.5 indexed customers respectively.

Table 5-10: Customer and user subsystem inputs for Beta

User and customer behaviour			
initial customer base	1	rate of customer acquisition per customer	0
initial user base	0	rate of customer acquisition per user	0
initial premium user base	0	rate of user acquisition per customer	0
user to premium conversion rate	0	rate of user acquisition per user	0
premium to user conversion rate	0	rate of premium user acquisition per cust.	0
standard customer lifetime	7.3	rate of premium user acquisition per user	0
standard user lifetime	0		
Capability development			
initial marketing selling competence	0.7	initial value delivering competence	0.7
MD years of improvement	1	VD years of improvement	1
new MS employee competence	0.3	new VD employee competence	0.3
effect of competence on ability to acquire customers			1
effect of competence on ability to acquire users			0
effect of competence on ability to acquire premium users			0
effect of competence on ability to service customers			1.5
effect of competence on ability to service users			0

Because the venture's marketing and selling employees have increased only slightly over the years, theory suggests that Beta's customer base also grows in minor amounts. This small growth would also fulfil the venture's small customer growth goal of 7% per year. Customers may decrease in the final growth state if the fewer marketing employees cannot acquire sufficient customers to make up for churn.

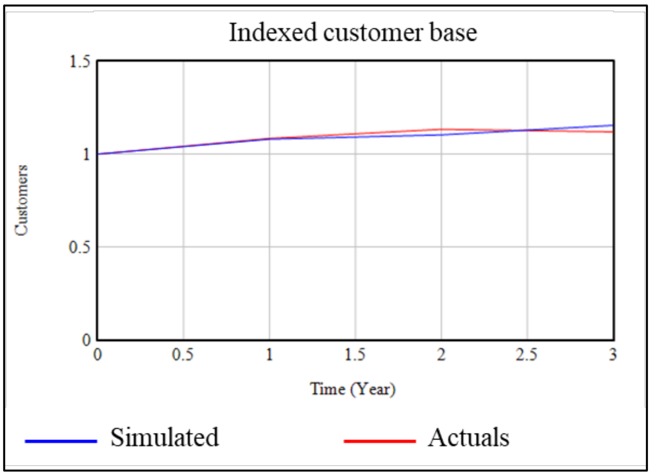


Figure 5-10: Customer subsystem outputs for Beta

Historical case data and the model support theory. They indicate a small increase of Beta's customer base in the first growth state (Figure 5-10). In the second growth state, the historical data shows a slight decrease in the customer base. The model does not fully capture this decrease. However, the model approximates the customer base very well, and the mismatch in the final year is minor.

5.3.3. Gamma

Because Gamma services customers (advertisers) and users (media owners), both initial values have been set (Table 5-11). The customer and user bases are thus both initialised at 0.5. Because the venture acquires new customers and users through its marketing and selling activities rather than through word-of-mouth, all word-of-mouth variables have been set to zero. Moreover, the Vensim software estimates standard customer and user lifetimes of 3 and 5.4 years respectively. Each fully equipped and capable marketing and selling employee can acquire 1.9 indexed customers and 6.2 indexed users per year. Its value delivering employees can service 4.4 and 1 indexed customers and users respectively. The same capability settings as for the other activities of Gamma have been utilised for these types of employees.

Table 5-11: Customer and user subsystem inputs for Gamma

User and customer behaviour			
initial customer base	0.5	rate of customer acquisition per customer	0
initial user base	0.5	rate of customer acquisition per user	0
initial premium user base	0	rate of user acquisition per customer	0
user to premium conversion rate	0	rate of user acquisition per user	0
premium to user conversion rate	0	rate of premium user acquisition per cust.	0
standard customer lifetime	3	rate of premium user acquisition per user	0
standard user lifetime	5.4		
Capability development			
initial marketing selling competence	0.7	initial value delivering competence	0.7
MD years of improvement	1	VD years of improvement	1
new MS employee competence	0.3	new VD employee competence	0.3
effect of competence on ability to acquire customers			1.9
effect of competence on ability to acquire users			6.2
effect of competence on ability to acquire premium users			0
effect of competence on ability to service customers			4.4
effect of competence on ability to service users			1

Gamma aims to increase its customer base in its first growth state. It increases its marketing and selling employees during this period to achieve this goal. Therefore, theory suggests an increase in customers during the first growth state. After its restructuring, the increase in the customer base should slow down or even decrease depending on employee ability to make up for customer loss due to churn. Because growing the user base is not a priority for Gamma, the user base should remain constant.

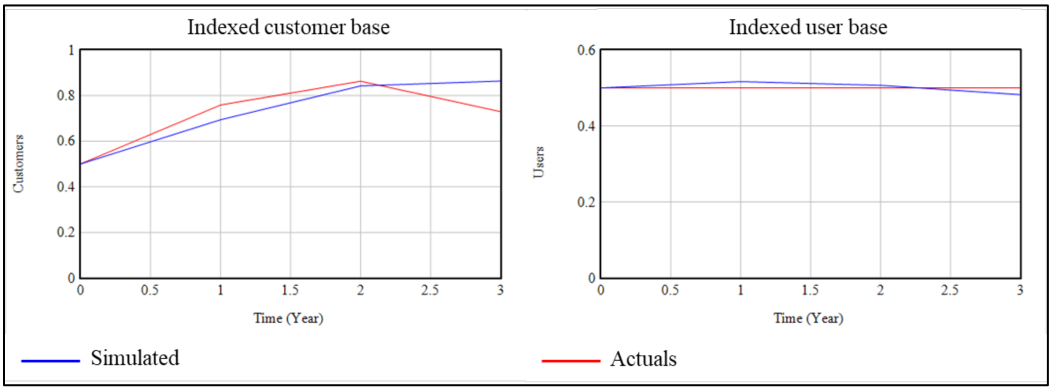


Figure 5-11: Customer subsystem outputs for Gamma

The model and data coincide with the theory and align, with minor differences (Figure 5-11). The venture's customer base increases by nearly 50% in the historical data and the model's approximations during the first growth state. In the historical data, Gamma then loses customers. However, the customer base in the model remains constant. Gamma's user base remains roughly constant throughout the years of simulation in the historical and model-generated data.

5.3.4. Delta

Because Delta provides its services to customers and users, both stocks' initial values have been set to 0.5 (Table 5-12). The Vensim software set the standard customer lifetime to 7.6 years. The short standard user lifetime of 0.5 years reflects that most users only stay a short time to make a booking and then discontinue the use of Delta's platform. Delta's initial marketing and selling employees can acquire 12.5 indexed customers and 7 indexed users per year. Its employees can service 1.7 indexed customers and 1.6 indexed users. The variables for its capability levels and development are the same as for Gamma in the previous activities.

Table 5-12: Customer and user subsystem inputs for Delta

User and customer behaviour			
initial customer base	0.5	rate of customer acquisition per customer	0
initial user base	0.5	rate of customer acquisition per user	0
initial premium user base	0	rate of user acquisition per customer	0
user to premium conversion rate	0	rate of user acquisition per user	0
premium to user conversion rate	0	rate of premium user acquisition per cust.	0
standard customer lifetime	7.6	rate of premium user acquisition per user	0
standard user lifetime	0.5		
Capability development			
initial marketing selling competence	0.7	initial value delivering competence	0.7
MD years of improvement	0.5	VD years of improvement	0.5
new MS employee competence	0.1	new VD employee competence	0.1
effect of competence on ability to acquire customers			12.5
effect of competence on ability to acquire users			7
effect of competence on ability to acquire premium users			0
effect of competence on ability to service customers			1.7
effect of competence on ability to service users			1.6

With its initial focus on user and customer growth and additional hires in marketing and sales, Delta should acquire new users and customers in the first growth state. After the restructuring, its customer base is likely to increase further due to its long lifetime. On the other hand, Delta's user base may decrease. Due to their low lifetime, the lower number of employees may be unable to acquire sufficient customers to make up for churn.

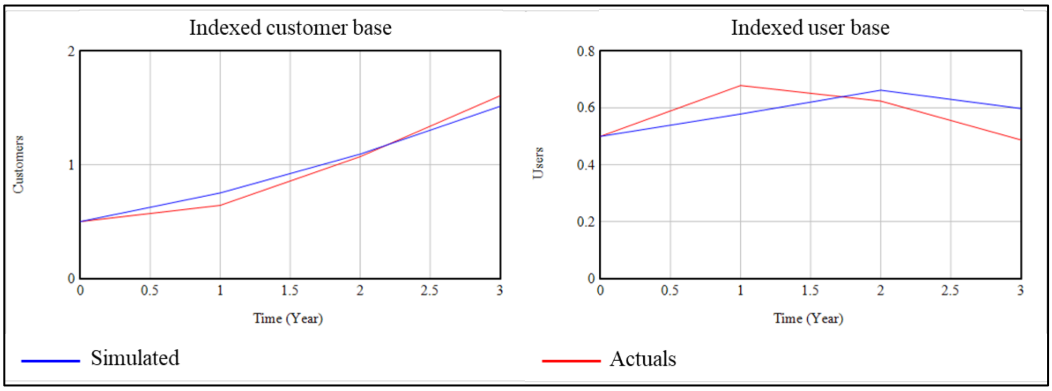


Figure 5-12: Customer subsystem outputs for Delta

The theoretical expectations are supported by the historical data (Figure 5-12) which indicate a rise in the customer base throughout the years and a peak in the user base in the first year, with a fall after its restructuring. The increase in the customer base is replicated well by the model. Its approximation of the user base is good except for the first year, likely due to a too low number of marketing and selling employees.

5.4. Value creation subsystem

This section tests the value creation subsystem introduced in the first section of the model formalisation chapter. Each subsection presents the exogenous inputs for this subsystem (see Table 4-1). Additionally, the subsystem depends on the outputs of the technology development and customer/user subsystems. The section presents value creation as a theoretical performance outcome and compares it to the revenue calculated in the model and the revenue reported by the case companies.

5.4.1. Alpha

Customers generate value from Alpha's product only through its technology. Therefore, all policy switches related to network effects are set to zero (Table 5-13). The venture claims to have developed a feature-rich application at the beginning of the simulation. Reviewing improvements made throughout the simulation period, it has been estimated that the venture can still improve its product by 50%. Therefore, the maximum technological quality has been set as 1.5. The Vensim software determined that each indexed dollar of investment into technology has an effect of 0.05 on the technological quality. With the restructuring plan introduced with its second growth state, the venture also begins to target larger customers. The average indexed number of employees per customer using the software has been used to approximate the usage intensity. After an initial value of one, this number of employees quadruples in the first growth state. The larger customers make the product available to 50% more employees. The variables related to users, premium users, and complementary products are set to zero.

Table 5-13: Value creation inputs for Alpha

Business model designs			
Customer direct network effect settings	0	Premium product advantage	0
Customer indirect network effect settings	0	Maximum technological quality	1.5
User direct network effect settings	0	Standard effect of investment in technology on tech. improvement	0.05
Customer indirect network effect settings	0		
Initial customer usage intensity	1	Initial user usage intensity	0
User and customer behaviour	**t: 0 - 2.25**	**t: 2.25 - 3.5**	**t: 3.5 - 6**
Maximum customer usage intensity	4	6	
New customer usage intensity	1	3	
Standard rate of adoption by customers	1	1	
Maximum user usage intensity	0		
New usage intensity	0		
Standard rate of adoption by users	0		
Complementary product	**time: 0 - 6**		
Quality of complementary products	0		

With these inputs and the inputs for the other subsystems, three different drivers of value creation can be identified for Alpha. Firstly, its rising customer base throughout the years, Secondly, an acceleration due to the larger customers in the second growth state. And lastly, a further acceleration in the third growth state due to technology improvements. However, the latter two value drivers are limited due to the technology s-curve and the maximum customer usage intensity.

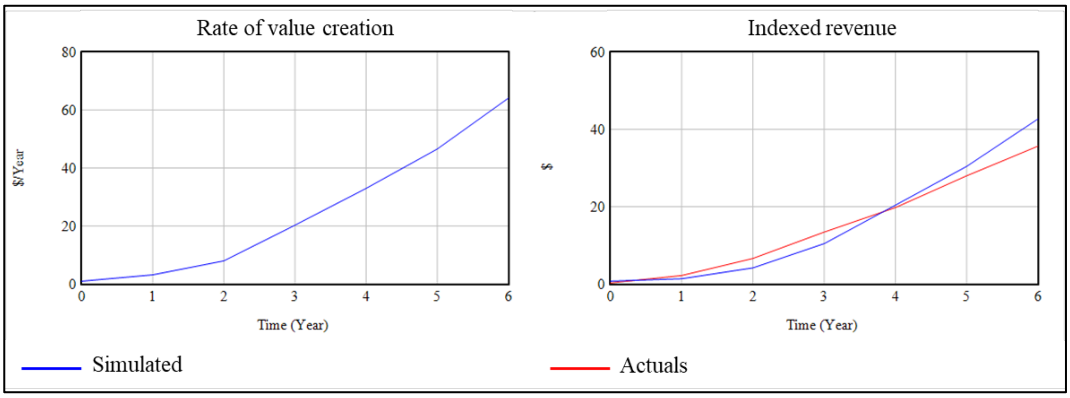


Figure 5-13: Value creation outputs for Alpha

Based on these inputs, the model approximates that Alpha increases the value it creates (Figure 5-13). Consistent with theory, an increase in the growth in value creation can be observed when the venture enters its second growth state. Interestingly, Alpha's growth in value creation accelerates when it reduces its customer growth target and pursues growth through a more attractive customer segment instead. At that point, the venture begins to target larger customers that generate greater value from the product. The development of value creation is also reflected in the venture's revenue. The model calculates it through the rate of value creation and the share of value captured from customers and users. Alpha's revenue grows like the rate of value creation but remains at a lower amount. This relationship is expected and has been explained by conceptualising value creation as the upper limit for revenue in the model development chapters. The revenue calculated within the model approximates well the revenue reported by the venture. However, the model's revenue has a small negative bias in the first two growth states and a positive bias in the third state.

5.4.2. Beta

As for Alpha, user variables and network effect switches are set to zero (Table 5-4). Customers derive value through Beta's technology, which the venture believes is very mature and industry-leading. Therefore, the venture's maximum technological quality has been set to 1.2 to reflect that its technology will only improve 20% through further development. The Vensim software estimated that each indexed dollar invested into technology improves the technological quality by 50. Throughout both growth states, Beta does not change its customer segment and does not indicate that customers change their usage behaviour of the software over time. Therefore, the variables related to customer behaviour have been set as one, reflecting their initial values. The same applies to complementary products. While Beta's software is compatible with a range of other software products, the company does not indicate a change in the quality of those products. Therefore, their quality is held constant as one.

Table 5-14: Value creation inputs for Beta

Business model designs			
Customer direct network effect settings	0	Premium product advantage	0
Customer indirect network effect settings	0	Maximum technological quality	1.2
User direct network effect settings	0	Standard effect of investment in technology on tech. improvement	50
Customer indirect network effect settings	0		
Initial customer usage intensity	1	Initial user usage intensity	0
User and customer behaviour	**time: 0 – 2.5**	**time: 2.5 – 3**	
Maximum customer usage intensity	1		
New customer usage intensity	1		
Standard rate of adoption by customers	1		
Maximum user usage intensity	0		
New usage intensity	0		
Standard rate of adoption by users	0		
Complementary product	**time: 0 - 3**		
Quality of complementary products	1		

The value created by Beta should increase with the technology improvements and growth in the customer base during the first growth state. Because technological improvements occur mainly in the first year, value creation should increase primarily in year one. Beta's revenue should also increase because competition does not change over the three years of investigation. However, the contract times should delay the effect of increased value creation on revenues (for competition and contract times, see value capture below). In the second growth state, the customer base stops growing. Moreover, Beta's technology developing employees are inadequate to maintain and develop new value-creating features. Therefore, both drivers of value growth diminish, and its rate of value creation should be constant in its second growth state.

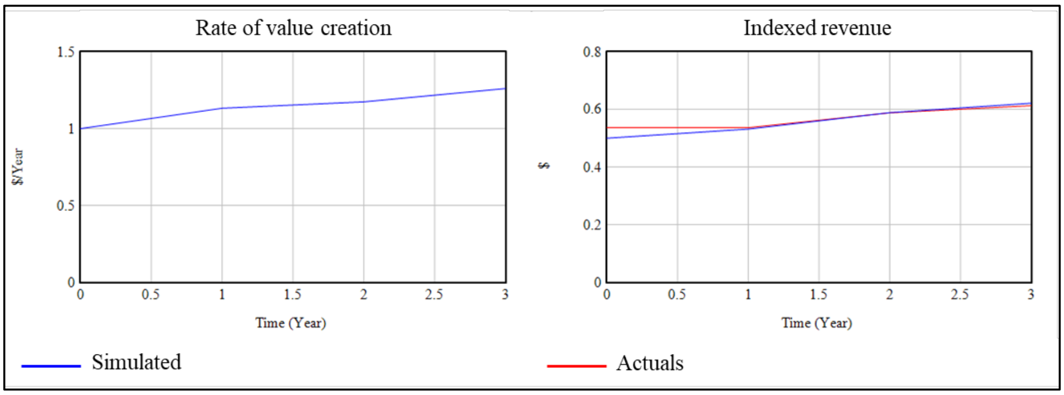


Figure 5-14: Value creation outputs for Beta

The model and case data support the theoretical claims (Figure 5-14). Value creation and revenue both grow with the customer base and technology improvements. The increase in revenue is delayed and takes place during the second year. The rate of value creation is constant and nearly stable in the second and third years. The revenue reflects this in year three due to contractual delays.

5.4.3. Gamma

Providing a marketplace, Gamma's customers and users benefit from interacting with the other group (Table 5-15). Therefore, indirect network effects settings have been set to reflect these positive network effects. However, due to competition within each base for advertising inventory and adverts, both bases also experience negative direct network effects. Gamma describes its technology as leading and sophisticated. Therefore, the maximum technological quality for mature products of 1.2 has been selected. The Vensim software set the impact of an indexed dollar invested into technology on the technological quality at 32. The venture does not indicate a change in the usage intensity of its user. However, the venture notices that new advertisers (customers) spend significantly less on the platform and increase their spending over time. This is particularly true for its international customers, who derive less value from the product. The company explains this with different privacy laws inhibiting its targeting algorithms and a lack of local media properties abroad. The analyst has set the new user usage intensity to 0.8, the rate of adoption to 2, and the maximum usage intensity to 1.2, to track the usage intensity of the average customer.

Table 5-15: Value creation inputs for Gamma

<table>
<tr><th colspan="4">Business model designs</th></tr>
<tr><td>Customer direct network effect settings</td><td>-1</td><td>Premium product advantage</td><td>0</td></tr>
<tr><td>Customer indirect network effect settings</td><td>1</td><td>Maximum technological quality</td><td>1.2</td></tr>
<tr><td>User direct network effect settings</td><td>-1</td><td rowspan="2">Standard effect of investment in technology on tech. improvement</td><td rowspan="2">32</td></tr>
<tr><td>Customer indirect network effect settings</td><td>1</td></tr>
<tr><td>Initial customer usage intensity</td><td>1</td><td>Initial user usage intensity</td><td>1</td></tr>
<tr><th>User and customer behaviour</th><th colspan="2">time: 0 - 2.75</th><th>time: 2.75 - 3</th></tr>
<tr><td>Maximum customer usage intensity</td><td colspan="3">1.2</td></tr>
<tr><td>New customer usage intensity</td><td colspan="3">0.8</td></tr>
<tr><td>Standard rate of adoption by customers</td><td colspan="3">2</td></tr>
<tr><td>Maximum user usage intensity</td><td colspan="3">1</td></tr>
<tr><td>New usage intensity</td><td colspan="3">1</td></tr>
<tr><td>Standard rate of adoption by users</td><td colspan="3">1</td></tr>
<tr><th>Complementary product</th><th colspan="3">time: 0 - 3</th></tr>
<tr><td>Quality of complementary products</td><td colspan="3">1</td></tr>
</table>

Based on the theory represented by the model, different value drivers determine Gamma's value creation. The first driver concerns Gamma's increasing technological quality. The company also increases its customers. This increase means Gamma creates value for more customers and more value per user due to network effects. However, the increasing customer base and technological quality only apply in the first growth state. Therefore, it should be expected that the rate of value creation increases slower or even falls during the second growth state. The rise in value creation may also not affect revenue because Gamma does not capture value from users. Therefore, value creation and revenue may not develop as closely as they did for Alpha and Beta. Value creation and revenues may also be disconnected for Gamma because of an increase in competition reducing its bargaining power to its customers (see value capture subsystem).

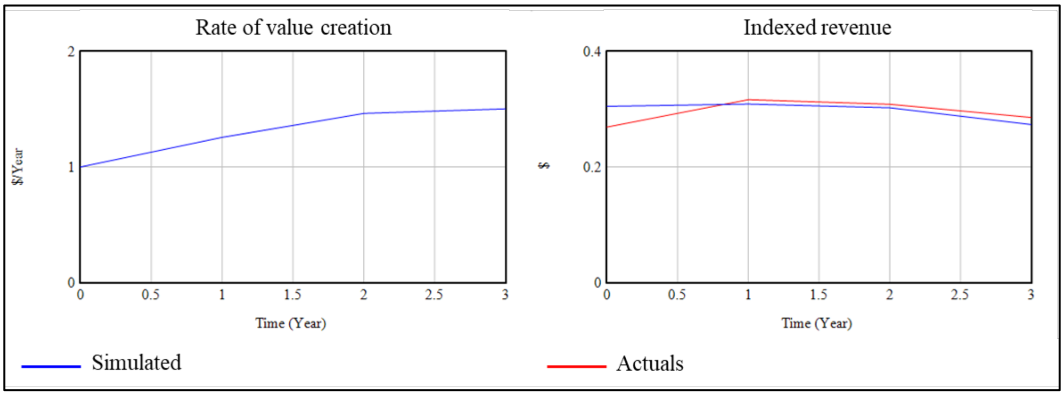


Figure 5-15: Value creation outputs for Gamma

The model replicates the theoretical expectation that value creation develops with the customer base and technology (Figure 5-15). Gamma's rate of value creation increases during the first two years and then remains stable in the model until the end of the third year. This behaviour tracks the growth in the customer base closely. Revenue has shown to be an appropriate proxy for value creation in the SaaS companies Alpha and Beta. However, it does not seem appropriate for Gamma, which its platform business model can explain. Gamma does not capture value from publishers (users) even though it creates more value for them. Therefore, there is a disconnection between value creation and revenue. The model can approximate the historical revenue well. Minor differences can be observed, particularly in the initial year of simulation. The difference at the beginning of the simulation is due to the annualisation of revenue when no full year of data is available in the model. The model approximates historical revenue well when this is not an issue.

5.4.4. Delta

Operating a platform connecting customers (travel providers) and users (travellers), customers and users both benefit from indirect network effects (Table 5-16). However, because travel providers compete for bookings on the platform, a larger number of travel providers make it less valuable for each customer. The same applies to user who compete for providers' limited inventory. Therefore, negative direct network effects hinder value creation for customers and users. Delta's maximum technological quality has been set to 1.2 to reflect its high maturity. Moreover, the Vensim software has set the impact of each investment on the quality to 110.

Table 5-16: Value creation inputs for Delta

Business model designs			
Customer direct network effect settings	-1	Premium product advantage	0
Customer indirect network effect settings	1	Maximum technological quality	1.2
User direct network effect settings	-1	Standard effect of investment in technology on tech. improvement	110
Customer indirect network effect settings	1		
Initial customer usage intensity	1	Initial user usage intensity	1
User and customer behaviour	**time: 0 - 1.75**	**time: 1.75 - 3**	
Maximum customer usage intensity	1		
New customer usage intensity	1		
Standard rate of adoption by customers	1		
Maximum user usage intensity	1		
New usage intensity	1		
Standard rate of adoption by users	1		
Complementary product	**time: 0 - 3**		
Quality of complementary products	0		

Theory suggests three different value drivers for Delta: the change in its user base, the change in its customer base, and its improving technology. The growth in Delta's customer base outweighs the fall in its user base. In addition, its technology improves. Therefore, Delta's value creation should grow throughout the years.

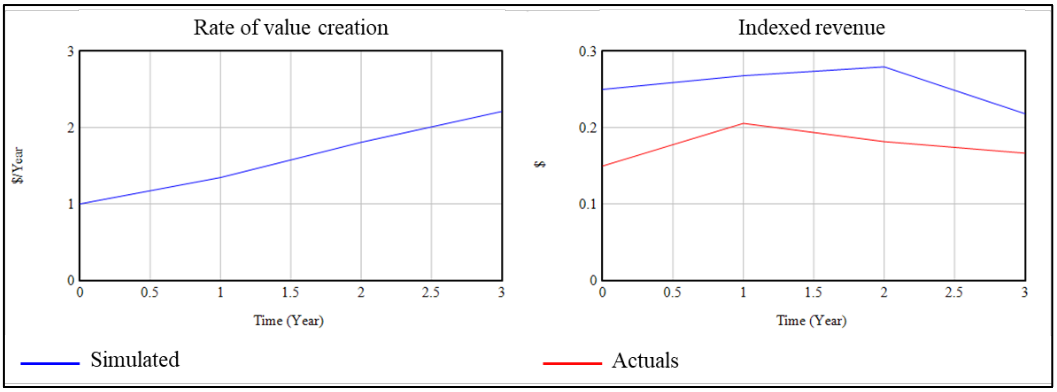


Figure 5-16: Value creation outputs for Delta

The rate of value creation supports the theoretical expectations of increases throughout the years (Figure 5-16). As for Gamma, revenue is not a good measure of value creation for Delta. The mismatch between value creation and capture for multi-sided business models explains this mismatch (see Gamma). The model can approximate the development of revenue directionally but overestimates it in all years.

5.5. Value capture subsystem

This section tests the value capture subsystem introduced in the second section of the model formalisation chapter. It depends on the human resources and capital assets, which require compensation to their input providers, depreciation and amortisation, and the value creation subsystem. Each subsection sets the exogenous inputs for each company (see Table 4-2) and compares model outputs to historical profitability measures.

5.5.1. Alpha

Alpha locks its customer into one-year contracts (Table 5-17). The company does not change its interaction with input providers and activity system throughout its growth states. Therefore, its costs per indexed employee remain constant. Depending on the activity, Alpha's costs per indexed employee are between 4.8% and 54.9% of initial total assets per year. Moreover, because the venture does not issue dividends, its cost of equity is zero. It pays 8.17% interest on its debt. With the change in its customer base as part of its second growth state, the company also experiences more intense competition for those larger customers. While Alpha operates in an oligopoly throughout the simulated years, it faces stronger competitors for its new target customer group. It is estimated that competitors' products are equal to the venture's product during the second and third growth states.

Table 5-17: Value capture inputs for Alpha

<table>
<tr><th colspan="6">Business model designs</th></tr>
<tr><td>Customer contract period</td><td>1</td><td colspan="3">Premium user contract period</td><td>0</td></tr>
<tr><th colspan="2">Input providers</th><th>t: 0 - 2.25</th><th>t: 2.25 - 3.5</th><th colspan="2">t: 3.5 - 6</th></tr>
<tr><td colspan="2">Cost of value delivering inputs</td><td colspan="4">7.2%</td></tr>
<tr><td colspan="2">Cost of marketing and selling inputs</td><td colspan="4">4.9%</td></tr>
<tr><td colspan="2">Cost of technology developing inputs</td><td colspan="4">4.8%</td></tr>
<tr><td colspan="2">Cost of firm managing inputs</td><td colspan="4">54.9%</td></tr>
<tr><td colspan="2">Cost of equity</td><td colspan="4">0.00%</td></tr>
<tr><td colspan="2">Cost of debt</td><td colspan="4">8.17%</td></tr>
<tr><th colspan="2">Competition</th><th>t: 0 - 2.25</th><th>t: 2.25 - 3.5</th><th colspan="2">t: 3.5 - 6</th></tr>
<tr><td colspan="2">Number of competitors</td><td colspan="4">0.5</td></tr>
<tr><td colspan="2">Strength of competitors</td><td>0.6</td><td colspan="3">1</td></tr>
</table>

The model calculates the share of value captured, return on assets, and net profit margin for six years using these inputs and those from the other subsystems. In the first growth state, value creation and input compensation increase. Therefore, it is not possible to predict performance development based on theory. This development depends on the balance of the two increases. However, with some caps on employee numbers and increasing value creation, the value captured should increase towards a maximum during the last two growth states.

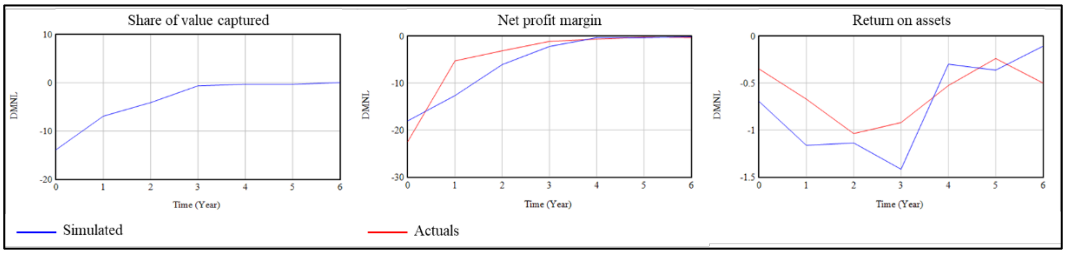


Figure 5-17: Value capture outputs for Alpha

Throughout the years of simulation, the model and net profit margin indicate improvements in performance outcomes while the venture loses resources every year (Figure 5-17). After one year of simulations, Alpha loses about five times its revenues. However, its share of value captured and net profit margin improve towards zero in a goal-seeking manner. Therefore, the model and historical data confirm the theory in the second and third growth states, where predictions were possible. However, the return on assets does not follow this behaviour. It fluctuates around -0.4 and -1, indicating that the venture loses about between half and all its assets per year. The model can approximate Alpha's trends in return on assets. However, the measure does not seem to be a suitable indicator for the share of value captured. Conceptual differences, such as the wrong basis to compare performance, have been noted in the model formalisation chapter that explain this difference (Subsubsection 4.2.3.2).

5.5.2. Beta

Beta locks its customers into contracts between one and three years. The middle value of two years has been set in the model (Table 5-18). Its costs per indexed employee remain constant and between 8.13% and 29.74% of total assets per year throughout its two growth states. While the venture does not pay any dividends, it pays about 4% interest on its debt. Many large software companies provide or develop similar applications, and many specialised companies compete with Beta. Therefore, the venture operates in a highlight competitive market, and the number of competitors has been set as one. It has been estimated that Beta's product is equal to the average competitors' product throughout the years.

Table 5-18: Value capture inputs for Beta

Business model designs			
Customer contract period	2	Premium user contract period	0
Input providers		**time: 0 – 2.5**	**time: 2.5 – 3**
Cost of value delivering inputs		23.30%	
Cost of marketing and selling inputs		29.74%	
Cost of technology developing inputs		20.48%	
Cost of firm managing inputs		8.13%	
Cost of equity		0.00%	
Cost of debt		4.08%	
Competition		**time: 0 – 2.5**	**time: 2.5 – 3**
Number of competitors		1	
Strength of competitors		1	

Due to constant competition, theory suggests that the bargaining power and share of value captured from customers should not change during the years of investigation. Therefore, changes in the share of value captured should only emerge from the shares of value lost. Due to its decreasing complementary assets and technological resources, the share of value lost to depreciation and amortisation should decrease over time and performance outcomes should improve. However, theory does not provide accurate predictions for the share of value lost to input providers in the first growth state. While some types of inputs decrease, other types increase, and the development of the share of value captured depends on the net effect of these changes. In the second growth state, all inputs and thus the compensation to input providers decrease while value creation and revenues remain nearly constant. Therefore, improvements in performance outcomes should be expected.

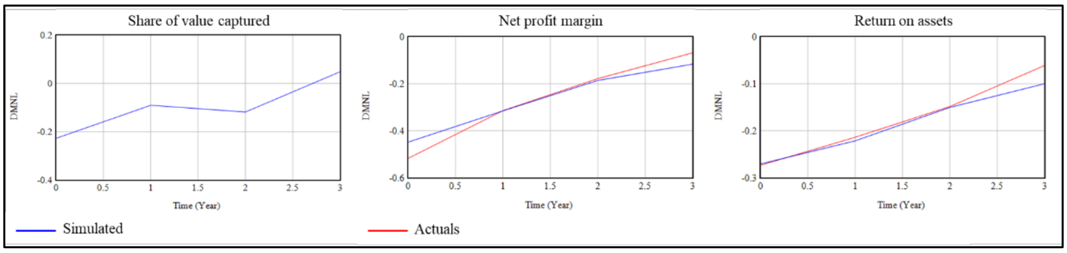


Figure 5-18: Value capture outputs for Beta

Overall, the model's and case history's performance measures support these theoretical expectations in the first growth state. Historical accounting measures improve throughout all years (Figure 5-18). The values calculated in the model can replicate this trend. However, its share of value captured diverges from this trend in the second year, where its rate of value creation does not grow.

5.5.3. Gamma

Gamma's customers can adjust their marketing spending for video campaigns dynamically. Therefore, a contract time of 0.25 years has been set to reflect that large enterprise customers with quarterly periods will review their spending in those intervals (Table 5-19). Throughout the growth states, the venture's indexed employees produce expenses of between about 4% and 60% of initial total assets per year. While it does not compensate provides of equity, Gamma pays 2.64% of interest on its debt. The company operates in a competitive market. Gamma claims that its product has features and advantages that competitors cannot match.

Therefore, the initial strength of competitors has been set to 0.8. However, the company notes an increase in competition after two years of simulation. It has been reflected by increasing the strength of competitors to 1.

Table 5-19: Value capture inputs for Gamma

Business model designs			
Customer contract period	0.25	Premium user contract period	0
Input providers	**time: 0 – 2.75**	**time: 2.75 – 3**	
Cost of value delivering inputs	59.15%		
Cost of marketing and selling inputs	37.22%		
Cost of technology developing inputs	4.74%		
Cost of firm managing inputs	13.05%		
Cost of equity	0.00%		
Cost of debt	2.64%		
Competition	**time: 0 – 2.75**	**time: 2.75 – 3**	
Number of competitors	0.8	1	
Strength of competitors	1		

With increasing employee inputs during the first growth state, Gamma's development of the share of value captured depends on the balance of increasing employee costs and the change in value creation. With its restructuring in the final year, Gamma should improve its share of value captured.

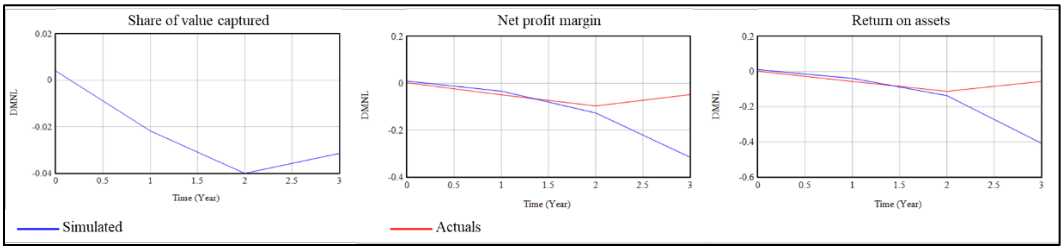


Figure 5-19: Value capture outputs for Gamma

The model's approximation of the share of value captured and accounting measures reflect the theory (Figure 5-19). During the first two years, Gamma's historical accounting measures fall. They rise after the restructuring. The share of value capture also reflects this pattern. However, the model's approximation of accounting measures diverges from them in the final year. This may be due to the mismatch between the timing of the restructuring and the fall in employee numbers. Due to later restructuring, the model's performance outcomes are low for too long. This mismatch then causes the underestimation of financial resources (see firm managing subsystem).

5.5.4. Delta

Delta operates in a continuously competitive marketplace. Its operations cost between 0.53% and 121% of initial total assets per indexed employee per year. This high cost reflects Delta's need to continuously acquire users with low lifetimes through marketing. Moreover, the company pays about 11.5% in interest on its debt (Table 5-20).

Table 5-20: Value capture inputs for Delta

Business model designs			
Customer contract period	0.125	Premium user contract period	0
Input providers		**time: 0 - 1.75**	**time: 1.75 - 3**
Cost of value delivering inputs		0.53%	
Cost of marketing and selling inputs		121.25%	
Cost of technology developing inputs		6.29%	
Cost of firm managing inputs		5.30%	
Cost of equity		0.00%	
Cost of debt		11.52%	
Competition		**time: 0 - 1.75**	**time: 1.75 - 3**
Number of competitors		1	
Strength of competitors		1	

Similar to Gamma, improvements in value capture performance outcomes should be expected when the venture restructures.

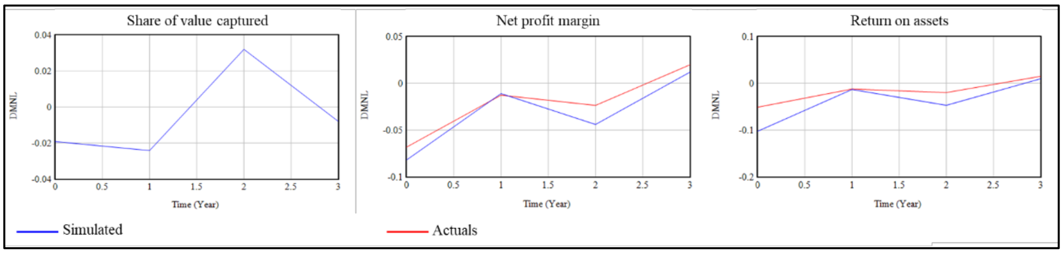


Figure 5-20: Value capture outputs for Delta

The historical case data and the model's approximations of accounting measures support the theoretical expectations. The share of value captured peaks just after Gamma restructured at the end of the second year (Figure 5-20). The net profit margin and return on assets improve during the final year. This delay is expected as accounting figures are annualised, and the restructuring only affects costs during the last quarter of Gamma's financial year.

Chapter 6: Scenario simulations

The previous chapter validated the model developed in this thesis. It established a sufficient degree of confidence in the model's ability to approximate the development of the case companies. The model can now facilitate simulations that reveal further insight regarding value creation and capture, their development, and the relationships between them. These simulations build on the model's conceptualisation, formalisation, and testing. The model conceptualisation using growth process theories and causal loops (Chapter 3) identified two types of dominant logic that affect the model's feedback loops. These two types refer to digital ventures that operate at their cap on employee numbers and those that strive to grow by hiring more employees. Model validation (Chapter 5) identified a third, combined case. It regards digital ventures transitioning from a dominant logic without employee caps to one with caps. These three dominant logics form the basis of the simulations in this chapter (Table 6-1). Each type of dominant logic shows a different performance development pattern, further investigated and confirmed using the exogenous variable groups identified during detailed, formal model development (Chapter 4). On the one hand, these groups include elements the management can influence while running their venture. These are the growth and improvement targets of the dominant logic and capability development variables expressing internal improvements. On the other hand, these variables relate to contextual influences in the venture's environment and business model design[24].

[24] These are the input variable groups outlined in the tables at the end of each subsystem in Chapter 4. In addition to the four groups utilised in this section, the formal modelling has also included a variable group related to accounting inputs. The model included these to ensure consistency for testing purposes between accounting figures calculated in the model and annual reports. Because they are not theoretically relevant (see the derivation of accounting measures in Chapter 4), they are not investigated further in this chapter.

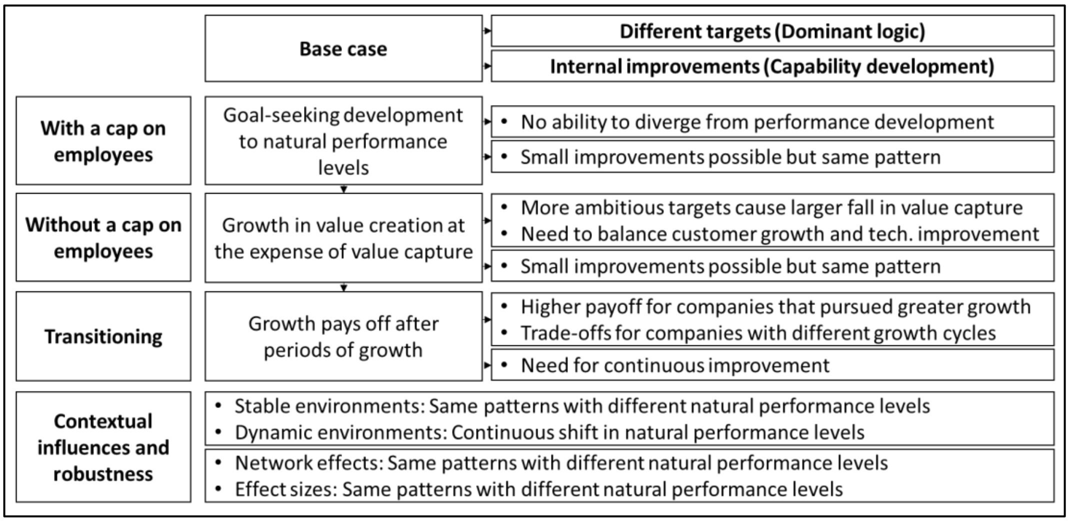


Figure 6-1: Overview of simulations and findings

The first section of this chapter develops a base case and investigates the performance development of a digital venture operating at its cap on employee numbers. It develops towards natural performance levels in a goal-seeking manner. These natural performance levels reflect limits to size, growth, and profitability. To raise these limits while maintaining their employee cap, companies can pursue different targets (reflected in the model by dominant logic variables) or improve their internal operations (reflected by capability development variables). While internal improvements enable a modest rise in performance outcomes, neither option allows the venture to alter its performance development significantly. Thus, to expand beyond their natural performance levels, ventures need to grow without capping their employee numbers and hiring more employees.

The second subsection investigates the same scenarios for growth-focussed companies without a cap on employee numbers. It shows the immediate and long-term relationships between growth in value creation and the share of value capture during the period of growth. Companies can improve their growth in value creation and limit adverse effects on the share of value captured by balancing customer growth and technology improvement targets. Operational improvements have the same effect. However, they cannot entirely escape the adverse effects of high growth, such as organisational turmoil and bankruptcy risks. Instead, they must eventually stop growing and introduce a cap on employee numbers. The third section of this chapter simulates this transition. It highlights that growth pays off after, not during, periods of growth. High growth has particularly adverse effects on value capture during the growth period. However, it also has more significant payoffs after periods of growth. Companies can further improve this payoff through continuous internal improvements.

The fourth section of this chapter confirms these development patterns along the contextual variables identified during detailed model development. It demonstrates these development patterns in different environmental conditions and across different business model designs. The final section of this chapter reflects on the simulations and their implications for the case companies in the previous chapter.

6.1. Dominant logics with a cap on employee numbers

This section illustrates and explains the performance development of digital ventures operating at their cap on employee numbers. Thereby, managers implement their desire to reduce delegation, remain in control of their ventures, or avoid growth risks (Davidsson, 1989; Hesse and Sternberg, 2017). However, not just owner-managers of digital ventures that want to maintain control limit their employee numbers. The case studies in the previous chapter show that larger companies also implement employee caps as part of restructuring activities to control costs. The performance development of companies with such employee caps is simulated under varying conditions in this section. Due to the model's indexing, simulations apply to smaller, owner-managed and larger, more mature firms. The first subsection, below, illustrates the model inputs and the development of a base case for comparison in further simulation. This base case exhibits a goal-seeking performance development towards natural levels for the rate of value creation and the share of value captured. However, managers and entrepreneurs may strive to improve the performance of their digital ventures beyond these natural performance levels. The detailed model developed (Chapter 4) outlines two options: pursuing more ambitious growth/improvement targets and internal improvements by affecting variables related to capability development. The second and third subsections alter input variables related to these two options to determine the development of performance outcomes under these two conditions.

6.1.1. Employee-capped base case

A reference mode is required to generate insights from simulations. This reference mode captures the baseline behaviour of the system and serves as a comparison for the outcomes of other simulations (Sterman, 2000; Warren, 2002). As the methodology argues, simulations should strive to be theoretically relevant and realistic (Davis, Eisenhardt and Bingham, 2007). This thesis investigates the performance developments and relationships that allow companies to develop an ability to capture value while growing their value creation. Therefore, the base case has been created to reflect a company that achieves an ability to capture value as it increases its value creation. The following illustrates the input variables and the performance development of this base case.

6.1.1.1. Model inputs for the employee-capped base case

The model input variables for the base case have been obtained in an interactive process going back and forth between all simulations in this chapter. This process ensures they are theoretically relevant. The values for input variables have been compared to the case studies to ensure they are within reasonable, realistic ranges. Input variables have been selected to (1) ensure the venture is initially loss-making, (2) allow feedback processes that improve the share of value captured, (3) employ a dominant logic that capitalises on these processes, and (4) ensure theoretical relevance. The summaries below outline the most important settings for each of these four criteria[25].

The level of competition and inputs costs have been used to create an initially loss-making base case:

- All operating input costs per indexed employee have been set at 25% of initial value creation to ensure that the company is initially loss-making. Thereby,

[25] Please see Appendix E for a complete and detailed list of input values.

all four costs together equal the initial rate of value creation of one, which is the maximum value the venture can capture.

- The initial strength of the average product of competitors and substitute providers is set as equal to the venture's product. The venture is operating in an oligopoly. These two settings reduce the share of value captured into the negative.

The following input values have been set to allow for feedback mechanisms that improve the ability to capture value over time:

- The maximum customer usage intensity is 1.5, the usage intensity of new customers is 0.5, and the rate of feature adoption is one year. These values allow the venture's customers to improve their usage intensity and develop switching costs over a period like those seen in case companies.
- The maximum technological quality has been set as 1.5. This potential allows the venture to improve its technological quality and value created per customer by up to 50%.
- The customer contract terms have been set at one year. This value is consistent with lengths among case companies in the previous chapter. It delays the effect of relative use value improvements on the ability to capture value.
- The venture's initial capability levels are assumed to have reached the level of "defined" on the capability maturity model (0.5). Capability improvement times have been set at one year, which is reasonable compared to values observed in case companies. The combination of these variables allows the venture to improve its employee productivity over time.

In the base case with a cap on employee numbers, the venture pursues the following objectives with the following constraints:

- The venture pursues a target customer growth rate of 25% per year and a target technology improvement rate of 10% per year. These values reflect that the venture is in the scaling-up process and focuses on growing its customer base while also improving its product.

- Employee numbers are capped at their initial level. Thus, the base case venture operates at its employee limits. All changes in performance outcomes are thus due to internal developments rather than changes in activity inputs.

The following settings have been placed to ensure that the model creates theoretically valuable insights rather than cofounding results:

- Accounting measures imported to the model, such as other assets or taxation, have been set as zero. They have been included in the model to achieve consistency between case companies' financial statements and model outputs for testing purposes. However, they are not theoretically relevant for the investigation below.
- All effect sizes that transform capabilities from soft to hard scales have been set to ensure that the venture runs at full capacity and achieves its goals with its initial employees and capability levels. Thus, the model is not affected by initial surges in hiring or layoffs to adjust capacities just after the beginning of the simulation. These settings ensure that the venture's performance development is due to theoretically relevant processes rather than eliminating operational imbalances.
- Initial financial resources have been set as one. The venture does not raise any capital to finance growth and technology improvements or return any debt or equity to investors. Thus, the venture's financial resources can be used as a cumulative measure of company performance.
- To create a simple base case, the business model design of a SaaS venture is used. The venture creates customer value based on its technological quality (see Alpha and Beta during model testing). The robustness of results for different business model designs is tested as a contextual influence in the final sections of this chapter.

6.1.1.2. Performance development of the employee-capped base case

With the above inputs, the base case's performance outcomes develop in a goal-seeking manner towards natural performance outcomes (Figure 6-2). As required for its set-up, the company does not initially capture value. Instead, its initial loss amounts to about 40% of the value it creates. Its share of value captured then improves and turns positive after about one year of simulations. While the venture’s share of value captured remains negative, its financial resources deteriorate. Once it has developed an ability to capture value, its financial resources accumulate. Because the rate of value creation and share of value captured increase throughout the five years of simulation, the rate at which financial resources accumulate accelerates. As discussed in the model development chapters, the financial resources represent cash and cash equivalents on the company’s balance sheet. The venture could, for example, pay these out to investors. Two important theoretical insights from this employee-capped base case (BaseC) are reviewed below. Firstly, even digital ventures operating at their employee caps can grow and improve their share of value captured. However, their performance outcomes are limited, and the venture develops towards limits in a goal-seeking manner.

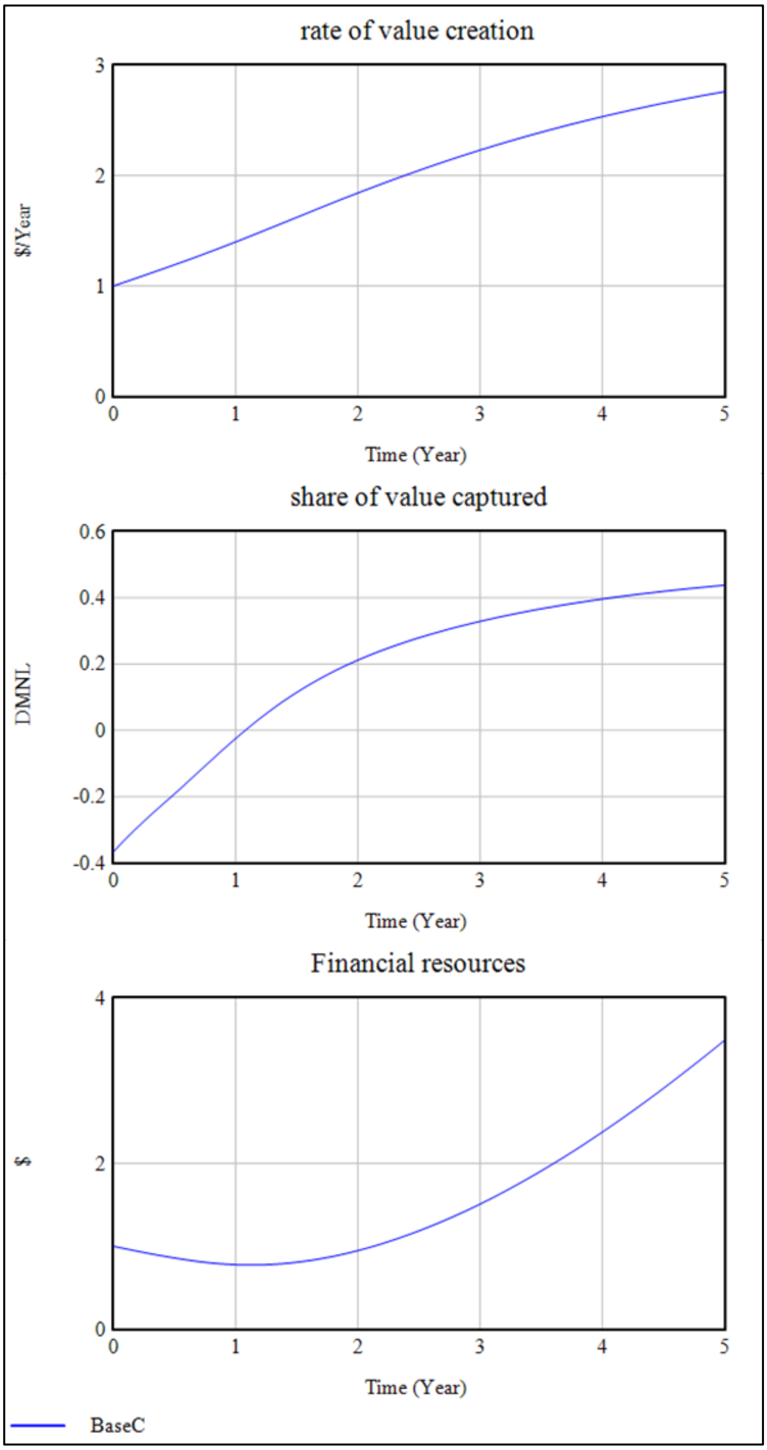


Figure 6-2: Performance development of employee-capped base case

A first theoretical insight from the BaseC scenario is that even companies unwilling to hire more employees can grow their rate of value creation and improve their share of value captured. The model explains the growth in value creation by the existing employees acquiring additional customers, improving the technology, and the improving customer usage intensity. The venture may even grow at accelerating rates due to capability improvements over time. This growth in value creation also improves the share of value captured. In a stable environment, the share of value captured from customers should increase as the SaaS venture improves its technology relative to its competitors. Thus, revenue as a fraction of value creation increases. Because the venture caps its employee headcount, it effectively caps the costs in absolute amounts too. At increasing rates of value creation, these costs expressed as a fraction of a growing rate of value creation decrease the share of value lost to input providers. Thus, the share of value captured increases due to an increasing share of value captured from customers and a declining share of value lost to input providers.

However, these improvements in performance outcomes are restricted for companies that operate at their employee cap. Instead, performance outcomes develop in a goal-seeking manner towards natural performance levels. Here, goal-seeking behaviour does not imply that the management has targeted these rates of value creation and share of value captured. As the inputs for the base case illustrate, the management was seeking improvements in its technological quality and increases in its customer base of, respectively, 10% and 25% per year. Without interfering feedback in the model, such targets alone would have caused continuous, exponential growth in value creation. Instead, goal-seeking refers to the behaviour of variables in System Dynamics models that are pushed towards specific values by negative, balancing feedback (Coyle, 1996; Ford, 2019). In the model developed in this thesis, these balancing feedback loops include, for example, churn rates increasing as capacity limits are exceeded. Other balancing loops are the s-curves regarding, for example, the customer usage intensities or technological quality. While capacity limits and the rates of technology development and customer acquisition increase through improving capabilities over time, a balancing loop also restricts capability improvements. Therefore, managements that cap their employee numbers will eventually fall short of achieving their customer growth and technology improvement goals. While growth in value creation is thus possible, these balancing loops introduce a maximum rate of value creation towards which the system develops. These limits on the rate of value creation also restrict the processes which can improve the share of value captured discussed above.

The natural performance levels achieved by the venture may differ from the target that the management wants to achieve. For example, the base case's management targets a 25% growth in its customer base per year. The goal-seeking development towards a natural rate of value creation implies that growth in value creation reduces to zero over time. Therefore, the venture's management may strive to improve its performance levels and allow it to perform better than its natural levels. Without lifting the cap on employee numbers, the model allows the management to alter two groups of variables. Firstly, variables related to their targets, which are part of the dominant logic. Secondly, variables related to the venture's capability development, which the management may alter to improve internal operations. The two subsections below illustrate the impact of changes to these variables on performance outcomes and development.

6.1.2. Different targets expressed in the dominant logic

Companies may pursue different targets even while restricting their employee headcount to initial levels. The model conceptualisation chapter has outlined two decision points: the target customer growth rate and target technology improvement rate. These reflect the management's goals and aspirations for percentage growth in its customer base and technological quality per year. They affect management's hiring decisions and thus the inputs to all other activities. Three different scenarios have been designed to investigate the impact of changing growth and improvement goals on companies with employee caps (Table 6-1). The venture targets an increased technology improvement rate of 20% per year in a first technology-focused scenario (TechC). In a second scenario, the venture is scaling up its customer base quicker by targeting a customer growth rate of 50% per year (ScaleC). The ambitious company in the third scenario targets the higher technology improvement and customer growth rate (AmbitiousC).

Table 6-1: Changes to employee-capped base case's dominant logic[26]

Variables	BaseC	TechC	ScaleC	AmbitiousC
Target customer growth	25%	25%	50%	50%
Target technology improvement	10%	20%	10%	20%

Regardless of their targets, companies that have hired the maximum number of desired employees still develop towards performance levels in a goal-seeking manner (Figure 6-3). The simulated companies with higher targets do not differ significantly from the base case operating at its employee limit. The TechC, ScaleC, and AmbitiousC scenarios develop towards similar rates of value creation, shares of value capture, and financial resources.

[26] This chapter abbreviates the scenario names when referring to them. The word standards for the scenario conditions. The letter indicates if employee numbers were capped (C), uncapped (U), or transitioning (T). For example, here the AmbitiousC scenario indicates more ambitious targets while capping employee numbers. The AmbitiousU scenario in the second section indicates the same targets but with uncapped employee numbers. The base case is shown in tables to compare changes to input values.

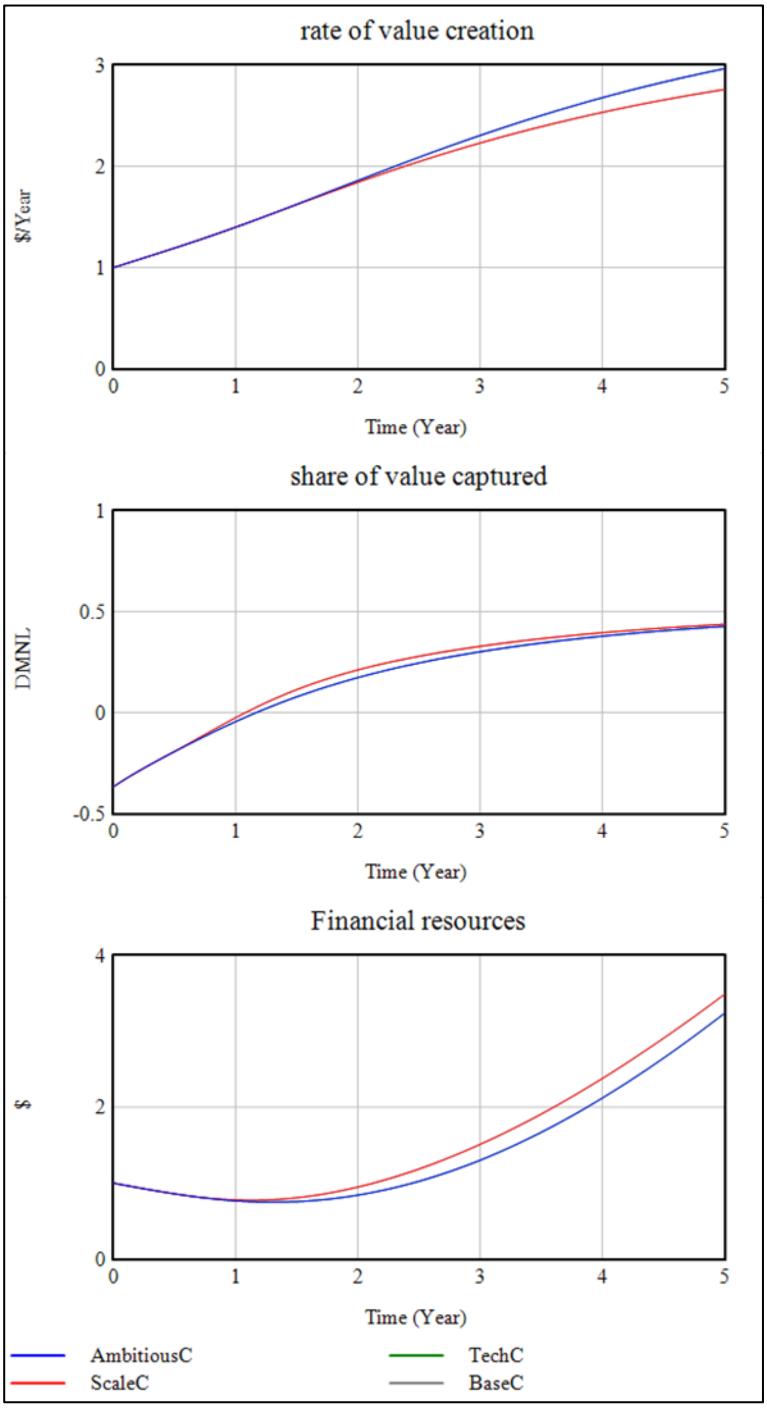


Figure 6-3: Effect of changes to employee-capped base case's dominant logic[27]

The simulations show that ventures operating at their employee caps can only achieve growth and improvement targets up to maximum rates. Because the venture will hire no additional employees, inputs to marketing, value delivering,

[27] Please not that in this figure, the lines for scenarios TechC and ScaleC are the same as for BaseC. Therefore, only one line is visible.

and technology development are limited. Therefore, the venture cannot increase its technology improvement and customer acquisition rate by hiring additional employees because achieving these rates is impossible through the current productivity improvements. While companies can improve their internal operations (see next subsection), they may also have to hire additional human resources to achieve more ambitious targets (see next section).

6.1.3. Internal improvement for capability development

Pursuing more ambitious targets does not allow digital ventures with employee limits to significantly alter their natural performance levels. Instead, the management may seek alternative routes to improve its performance outcomes. The other option that employee-capped ventures have in the developed model is to improve their internal operations and raise the productivity of their employees. Because capabilities have been conceptualised as productivity levels, the management may thus strive to affect variables related to capability development. In the conceptual model, capabilities deteriorate through hiring and improve through learning based on dynamic capabilities, with which they form a balancing loop. The detailed description of the model introduces a range of exogenous variables affecting the development of capabilities. These include the time required to improve productivity levels and train new employees, the capability levels of new employees, and the employee turnover rate. Three scenarios investigate the impact of changing these variables on performance outcomes and their development (Table 6-2). The first scenario lowers capability improvements times from one year in the base case to half a year (TrainingC). The second scenario reduces the capability levels of the average new employee from 0.3 to 0.1 on the capability maturity model scale (NewEmpsC). The final scenario investigates the impact of reducing the employee turnover rate from 30% to 10% (TurnoverC).

Table 6-2: Changes to employee-capped base case's capability development

<table>
<tr><th>Variables</th><th>BaseC</th><th>TrainingC</th><th>NewEmpsC</th><th>TurnoverC</th></tr>
<tr><td>Capability improvement times</td><td>1</td><td>0.5</td><td colspan="2">1</td></tr>
<tr><td>New employee capability level</td><td colspan="2">0.3</td><td>0.1</td><td>0.3</td></tr>
<tr><td>Employee turnover rate</td><td colspan="3">30%</td><td>10%</td></tr>
</table>

Shorter improvement times and lower turnover rates improve both performance outcomes compared to the base case. Lower capability levels of new employees reduce performance outcomes (Figure 6-4). However, company performance outcomes still develop in a goal-seeking manner towards different natural performance levels.

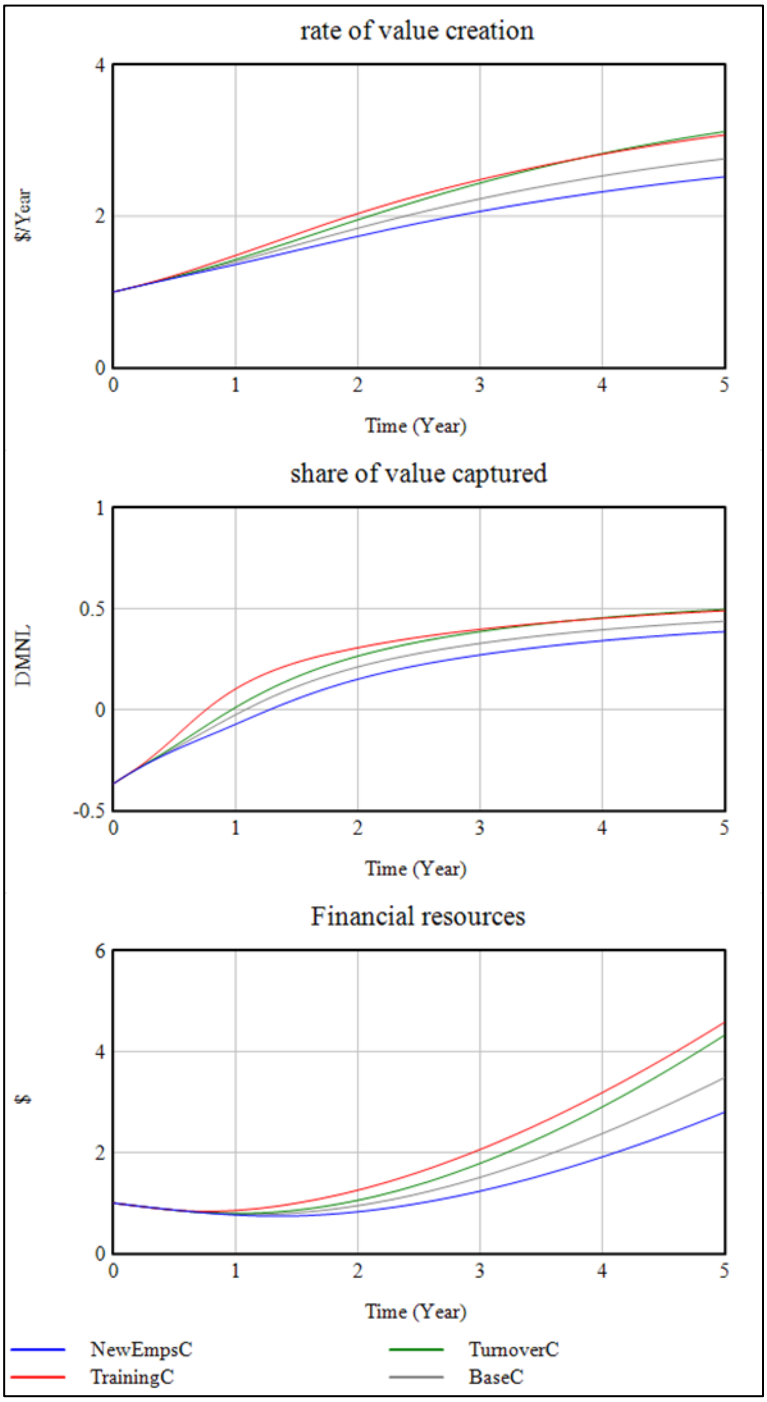


Figure 6-4: Effect of changes to employee-capped base case's capability development

Changing variables related to capability development as part of internal improvements alters natural performance levels. Lowering turnover rates, lowering training time, and increasing the competence of new employees increases the capability level of the firm. For example, at lower turnover rates, trained employees are replaced less frequently by employees who lack experience. Thus, the average productivity level of employees increases. With these increased capability levels, the venture's employees can achieve a greater output in their activities. As shown when investigating different targets, the constraints for companies operating at their employee cap are not the management's target but what its current employees can achieve. Therefore, the venture's employees can acquire and service more customers and improve the technology faster with improved capability levels. These higher capacities increase the rate of value creation towards which the venture develops. Because costs are constant due to restricted inputs, the share of value captured improves with the rate of value creation.

However, changing capability development variables does not change the fundamental goal-seeking patterns of performance development. Because the venture still caps employee inputs to its activities, changes to the outputs of activities can only be expanded through capability improvements. Internal improvements, as explained above, increase the capabilities and employee productivity of the firm. However, improvements are governed by a balancing feedback loop and limited to best practice. Thus, capabilities settle at a higher level. These higher capability levels ultimately determine the rate of value creation and thus the share of value captured towards which the firm develops.

6.2. Dominant logics without a cap on employee numbers

The simulations above have focussed on companies that cap their employee headcount to maintain control over the companies. Ventures with such caps exhibit goal-seeking development towards natural performance levels. While internal improvements can raise these performance levels, ventures cannot diverge from goal-seeking behaviour while maintaining their employee cap. Thus, the ventures that want to improve performance levels further need to uncap their employee headcount. In practice, such digital ventures focus on scaling up their customer base and improving their technology even if their ambitious goals require increasing their headcount.

The simulations in this section explore the performance development of digital ventures without a cap on employee numbers. This section first outlines the performance development of a base case without employee caps. It illustrates growth in value creation at the expense of the share of value captured. The venture can thus diverge from its goal-seeking development in value creation. However, it does so at the expense of capturing value and accumulating financial resources. To grow faster or reduce the adverse effects on value capture, managers may pursue different growth/improvement targets and internal improvements. Simulations show that an ambitious and customer-focussed dominant logic can increase the growth in value creation. However, such ambitious ventures also exhibit a more severe fall in the share of value captured and the venture's financial resources. Internal improvements and a balance of targets can accelerate growth and soften the adverse effects on the share of value captured. However, the share of value captured remains lower than in employee-capped scenarios. Therefore, companies may eventually stop growing in order to improve their share of value captured, which the next section of this chapter reviews.

6.2.1. Employee-uncapped base case

The simulations in this section use the inputs of the base case introduced in the previous section. They only eliminate the employee caps of that base case to simulate companies that grow their customer base and improve their product without capping their employee headcount. Simulating this base case for employee-uncapped companies (BaseU) illustrates that such companies can increase their value creation rate exponentially. BaseU diverges from the goal-seeking behaviour uncovered in the previous section (Figure 6-5). However, it does so at the expense of the share of value captured and financial resource accumulation. This growth in value creation, the trade-off with the share of value captured, and the impact on financial resources are reviewed below.

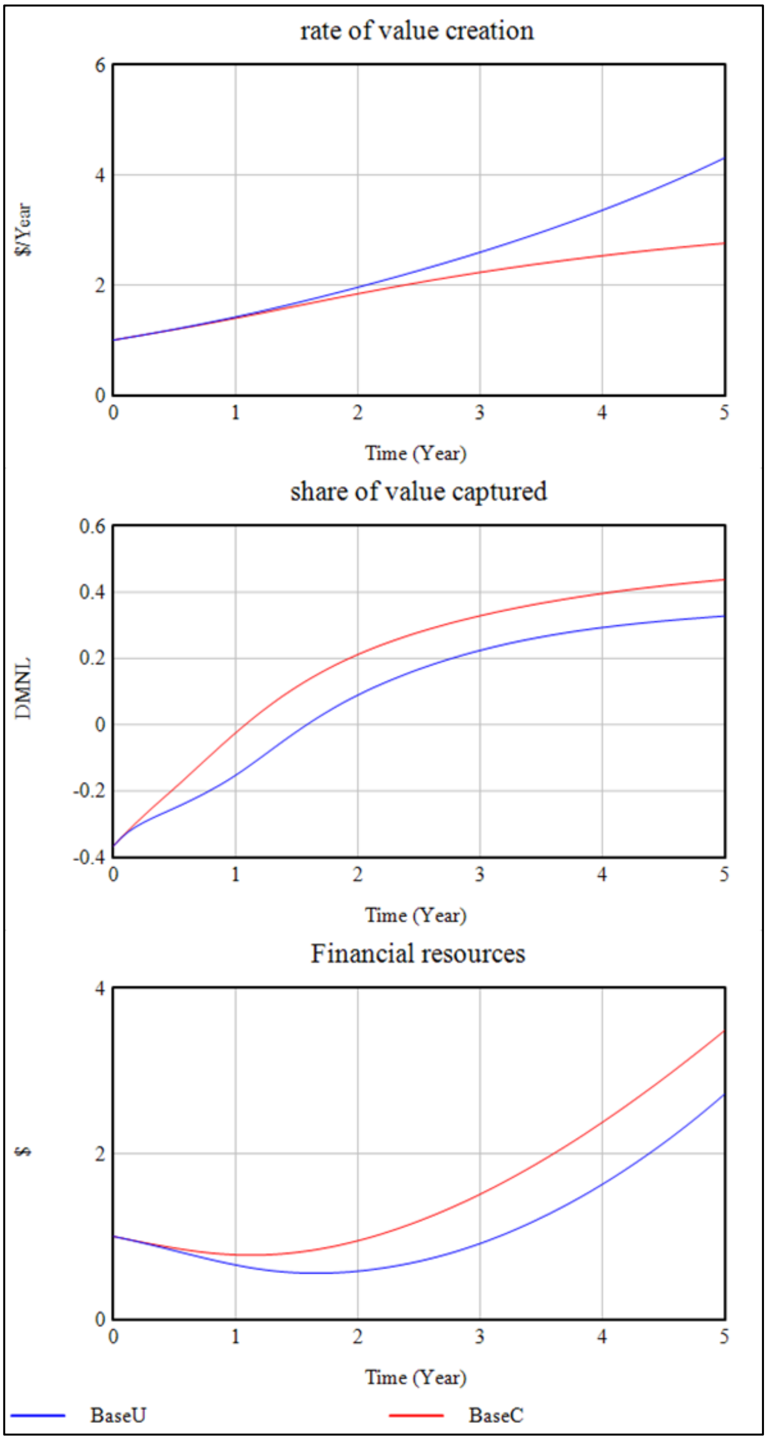


Figure 6-5: Performance development of employee-uncapped base case

A first insight is that companies with a growth-based dominant logic that do not cap their employment numbers can increase the value they create. They are not constrained by all the limits that affect companies with employee caps. Instead, they can grow their customer base and improve their technology, increasing their value creation. Companies achieve this growth by hiring additional employees to acquire more customers, service those new customers, improve their technology, and manage the larger firm.

The simulation also shows trade-offs between growth in value creation and the share of value captured. Compared to the BaseC, BaseU develops towards a lower share of value captured. The model explains this lower level through the lower capabilities of the average employee. Every time new employees are hired to achieve updated growth and improvement goals, capabilities fall due to new employees' lack of firm-specific knowledge. Therefore, more employees are required to acquire, service, and manage a growing firm. The share of value captured also develops towards a set level. On the one side, capability improvements and capacity filling up should improve the share of value captured. On the other hand, the continuous expansion lowers capabilities and creates new capacity. The share of value captured develops to the level at which these opposing forces balance. Due to a lower share of value captured, companies face a trade-off between growing the value they create and capturing a share of that value.

Due to the lower share of value captured, these companies' financial resources lag behind the venture with employee caps. This deeper fall poses a risk of bankruptcy. BaseU's financial resources remain above zero. However, if the company had lacked an ability to capture value for longer, its financial resources would have fallen below zero. Therefore, growing ventures need to ensure they raise sufficient capital to finance their growth and avoid bankruptcy. Using the financial resources to measure cumulative performance, BaseC has been more successful than BaseU. After five years, BaseC has more than tripled its financial resources but BaseU has just over doubled them.

The simulation above shows that while companies without employee caps can achieve exponential growth in value creation, they do so at the expense of the share of value captured and financial resource accumulation. Managers of digital ventures may thus strive to improve the rate of growth in value creation and soften the adverse effect on the share of value captured. As outlined in the previous section, the model allows them to pursue different targets as part of their dominant logic or through internal improvements affecting capability development. The two subsequent subsections investigate the impact of these changes on the performance outcomes of companies without employee caps.

6.2.2. Different targets expressed in the dominant logic

Managers and entrepreneurs of digital ventures may pursue more ambitious and different customer growth and technology improvement targets. They may do so to increase their growth in value creation or alter the development of their share of value captured. The same scenarios as for employee-capped companies (Table 6-1) are utilised to simulate different targets reflected in the dominant logic. The performance development patterns with more ambitious target rates are similar to BaseU. They include exponential growth in value creation and development towards a lower share of value captured. However, ScaleU and AmbitiousU also experience an immediate fall in the share of value captured (Figure 6-6). The different scenarios show different growth rates in value creation and different levels towards which the share of value captured develops. Moreover, ventures need to balance customer growth and technology improvement.

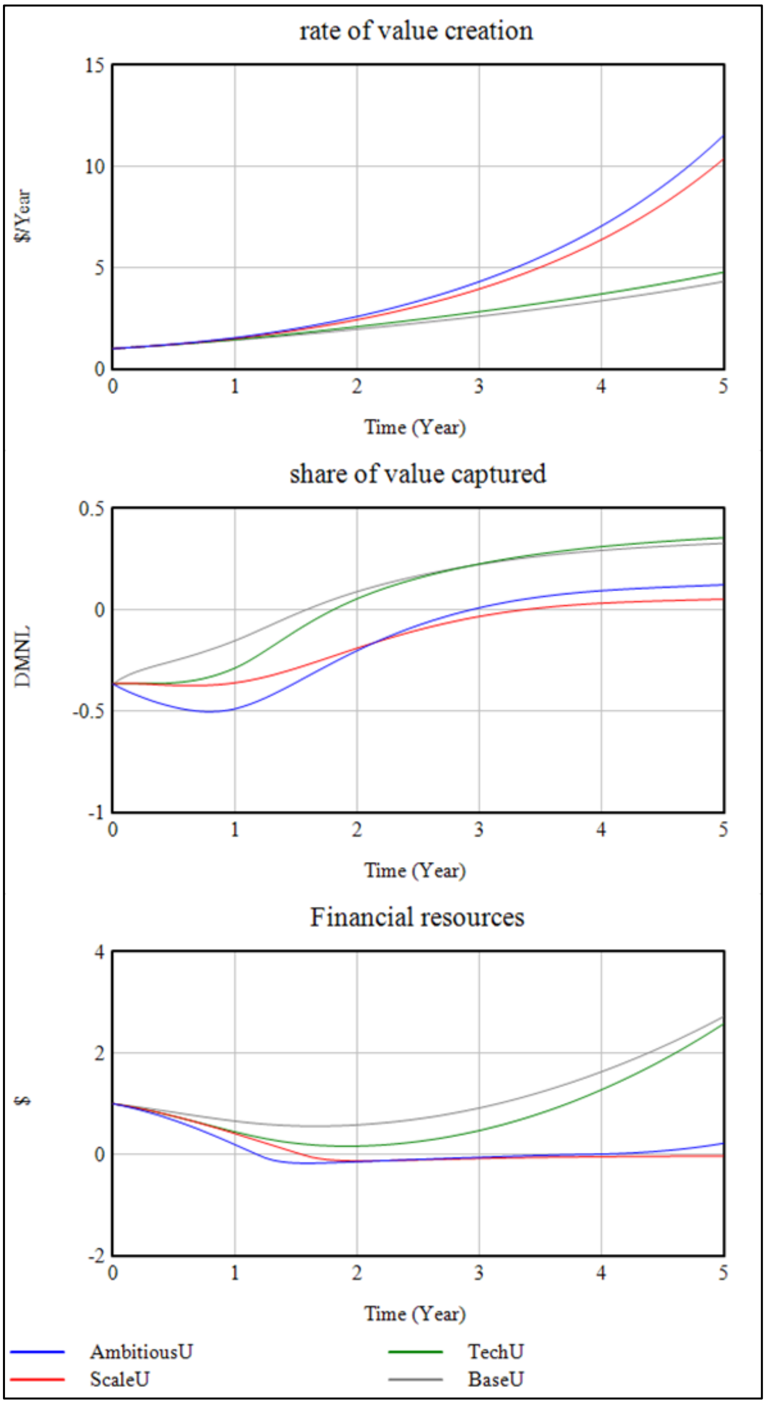


Figure 6-6: Effect of changes to employee-uncapped base case's dominant logic

A first important insight of the higher target growth and improvement rates is that they exaggerate the performance development observed in the BaseU scenario. Firstly, higher targets accelerate the growth in value creation, identifiable through the value creation's curves' steepness. Ventures achieve higher growth in value creation by hiring additional employees. Secondly, companies with more ambitious targets develop towards lower levels of value capture because they continuously need to hire more employees, resulting in lower average capability levels. An additional effect concerns the immediate fall in the share of value captured that affects ScaleU and AmbitiousU. Their shares of value captured immediately decreases due to timing differences between inputs that it must pay for and the growth in value creation. The venture must hire additional employees with lower productivity due to their lack of firm-specific knowledge to achieve more ambitious growth goals. While the venture pays these employees as soon as they are hired, these employees' outputs lag behind the average employee until they have been trained. Lastly, due to the lower share of value captured, financial resources become suppressed for longer. For ScaleU and AmbitiousU, they even turn negative. Real companies would have gone out of business at that point.

Companies that balance customer growth and technology improvements can soften the impact on the share of value captured. While focusing on scaling up the customer base allows exponential growth in value creation, improving the technology improves the share of value captured. Ventures that focus on customer growth can grow exponentially, whereas ventures that focus on their technology can only improve it along the technology s-curve. Thus, focusing resources on achieving more ambitious customer growth allows ScaleU to grow its rate of value creation faster and to higher levels. However, TechU's share of value captured reaches a value above BaseU's. The impact of technology development can explain these differences. With increasing technological quality, the venture's product becomes, relative to competitors and substitutes, more attractive to customers. Thereby, TechU increases its bargaining power to customers, resulting in more value being captured from them. Balancing both targets has the additional advantage of spreading the development costs over more customers. Thus, both targets are complementary and allow AmbitiousU to achieve exponential growth in value creation, while softening the negative impact on the share of value captured compared to ScaleU.

The simulations in this subsection have shown that managers can increase the growth in value creation by changing their dominant logic's targets. However, the more ambitious these goals, the steeper the immediate fall in value capture. Moreover, the level towards which the share of value captured develops may be lower. This poses a significant risk of bankruptcy for companies that pursue ambitious customer growth goals. They must thus raise sufficient funding to remain solvent. Additionally, managers may improve performance through internal improvements.

6.2.3. Internal improvement for capability development

Managers and entrepreneurs of digital ventures may strive to improve their internal operations and employee productivity to increase their growth in value creation. These may also soften the impact of growth on the share of value captured and the financial resources. The impact of lower training times (TrainingU), employee turnover (TurnoverU), and new employees' productivity (NewEmpsU) are explored for companies without employee caps. The same scenario set-up for companies with employee caps (Table 6-2) investigates internal improvements. These companies can significantly soften the fall of the share of value captured (Figure 6-7).

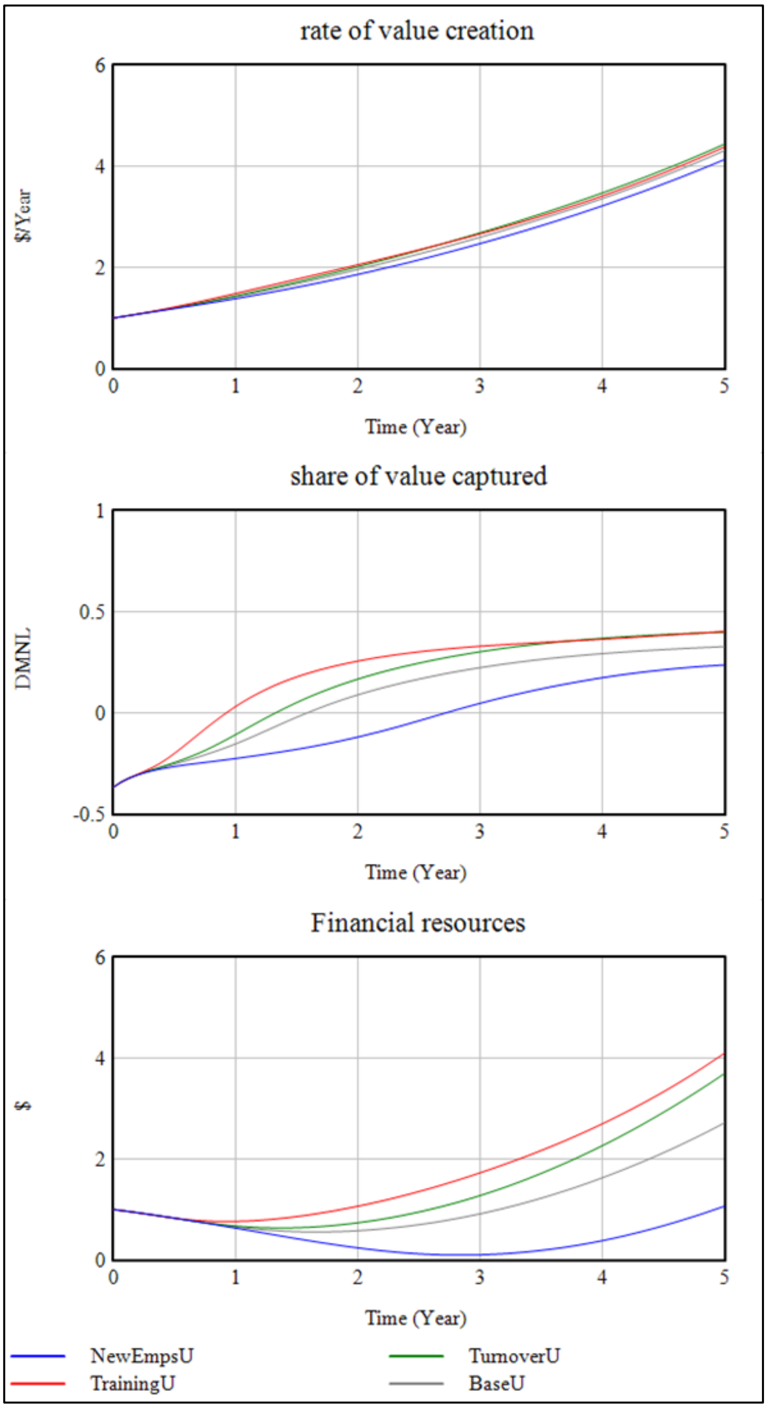


Figure 6-7: Effect of changes to employee-uncapped base case's capability development

Digital ventures without employee caps can soften the fall in the share of value captured through internal improvements (affecting variables related to capability development). As explained for BaseC, shorter training times, lower employee turnover, and a higher level of new employees' competence increase the capability level of the firm. This level expresses the venture's average employee productivity. However, whereas capability improvements affected both performance outcomes of employee-capped companies, their impact on employee-uncapped companies has a focus on the share of value captured. At higher productivity levels, the venture achieves its customer growth and technology improvement goals with fewer employees. Therefore, ventures that improve internally need to compensate fewer input providers for their contribution to activities. Compared to BaseU, internal improvements thus soften the fall in the share of value captured when they initialise the growth process. The venture also develops towards higher levels for the share of value captured. Minor differences in the rate of value creation can also be observed but these should entirely depend on the venture's targets. These differences occur because the management is never perfectly aware of the venture's actual productivity levels. Instead, their productivity estimates adjust over time to their actual values. However, by then, productivity has moved on to a new value. For example, with faster training times, the venture's management always underestimates productive levels and hires more employees than were required to achieve its targets. Due to more employees with improved capabilities, the management overachieves, leading to slight variations in the rate of value creation.

Thus, digital ventures could significantly soften the negative effect of growth on the share of value captured. However, the share of value captured and financial resources as a cumulative performance measure still suffer during the growth process.

6.3. Transitioning between dominant logics

A venture's share of value captured suffers during the growth in value creation. Ventures may thus decide to transition from a dominant logic focused on scaling up and improving the technology without employee caps to a dominant logic with employee caps. Research also argues that they may do so due to market constraints, fulfilled ambitions, or internal constraints (Levie and Lichtenstein, 2010; Brown and Mawson, 2013). Such transitions have also been observed and described in the case simulations during model validation, where all companies restructure and cap or reduce their employee numbers after periods of growth. A prime example of this development is Alpha. It grows exponentially during its first growth state and then maintains a constant number of marketing employees for nearly four more years. This constant employee number is below its headcount in the growth period. This section investigates such transitions, which indicate that growth pays off after periods of growth. These benefits are particularly high if higher growth rates have previously been pursued. In addition, this section explores different growth cycles, different restructuring magnitudes, and the impact of internal improvements.

6.3.1. Transitioning base case

This subsection investigates the impact of transitions from dominant logics without a cap on employee numbers to dominant logics with a cap. The simulation follows BaseU for another five years. During the first five years, the transitioning base case (BaseT) exhibits the same conditions and development as BaseU. After five years, the venture's employee numbers are capped at the level they reached. The simulation is then continued for another five years with those caps on employee numbers. Thus, BaseT reflects a venture that grows for five years and then no longer increases the inputs to its operations. The simulation shows that the venture returns to the goal-seeking development of performance outcomes discovered for companies operating at their cap on employee numbers (Figure 6-8). The figure illustrates that growth pays off after periods of growth due to higher levels in both performance outcomes. These lead to a much-accelerated accumulation in financial resources.

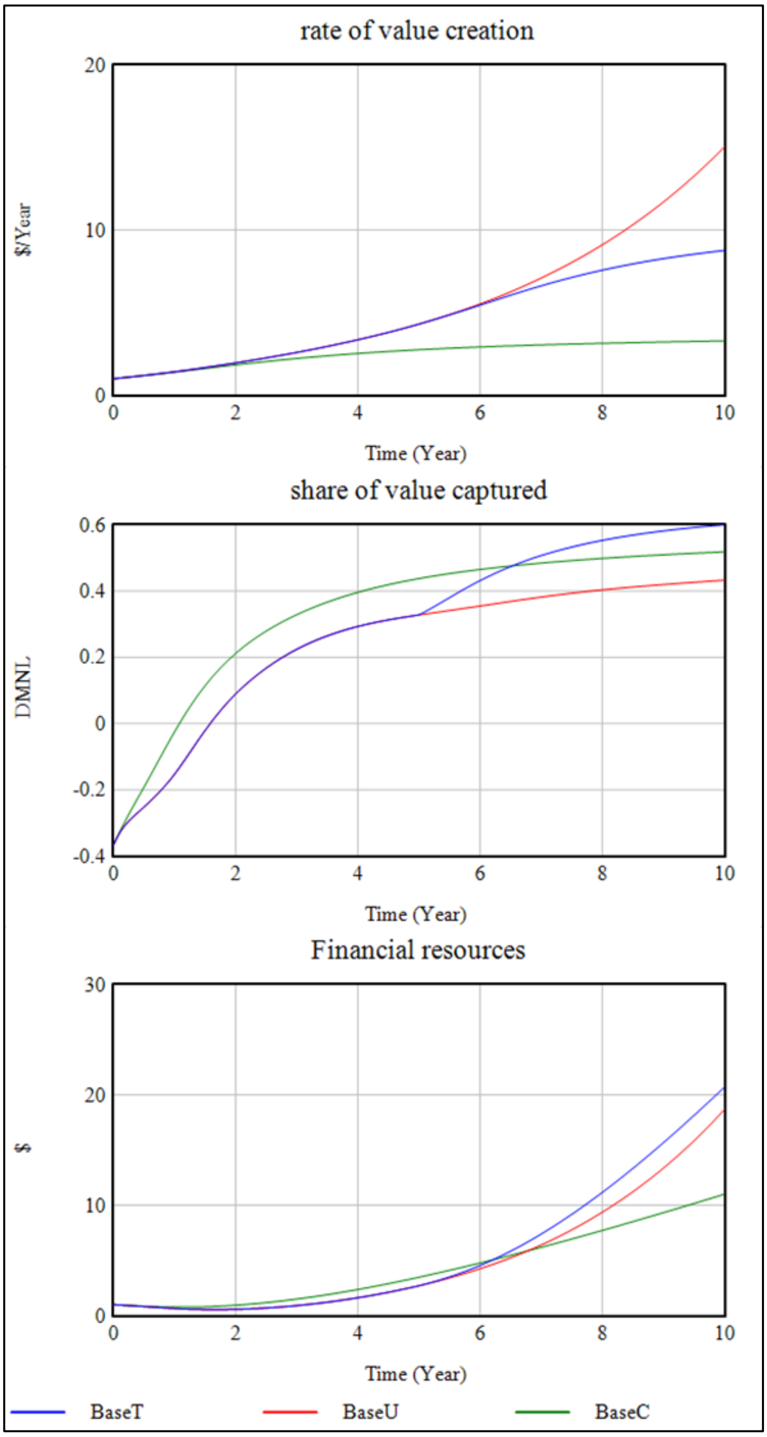


Figure 6-8: Performance development of transitioning base case transitioning

BaseT illustrates a long-term trade-off between the growth in value creation and the share of value captured. Once companies introduce employee caps, their performance outcomes develop in a goal-seeking pattern again. However, their value creation rate after the growth period develops towards a higher level.

Metaphorically, companies have created a much larger value pie from which they can now capture value.

The digital venture develops towards a higher share of value captured due to economies of scale. For example, BaseT can spread technology development costs and the amortisation of technological resources over more customers and value creation. Combined, the higher rate of value creation and share of value captured cause significantly faster growth in its financial resources once BaseT transitions. Thus, periods of growth pay off once the venture stops growing. Companies must decide whether the higher rate of value creation and share of value captured after growth outweigh the lower share of value captured during the growth period. They must also avoid the risk of bankruptcy during the growth period mentioned above. The initial period of growth pays off for BaseT because its financial resources accumulated over the ten years of simulation overtake the base cases with and without employee caps.

The above transition from an uncapped to a capped dominant logic illustrates that growth pays off after periods of growth. However, it raises questions about maximising this benefit of growth. As argued before, the management's levers are the target expressed in their dominant logic and pursuing internal improvements affecting capability development. These are reviewed in the two subsections below.

6.3.2. Different targets expressed in the dominant logic

The transitioning base case has illustrated that companies benefit from growth after they stopped growing employee inputs. The first two sections of this chapter have argued that companies may pursue different growth and improvement targets. Transitions introduce additional complexities to the development of value creation and capture during the growth process. Firstly, companies may not just maintain but also reduce their employee numbers when transitioning. Secondly, companies may also switch back and forth between dominant logics. Below, the impact of different targets, reductions, and growth cycles are explored.

6.3.2.1. *Different targets throughout the simulation*

Managers can pursue different targets. These targets do not affect companies with employee caps significantly because they remain constrained by their employee productivity. However, they significantly affect employee-uncapped companies. Simulations have identified that companies can pursue more ambitious targets and grow their rate of value creation faster. However, they do so at the expense of the share of value captured. Different target magnitudes expressed in the dominant logic should thus be tested for transitioning companies. The simulations for employee-uncapped companies (see subsection 6.2.2) have been continued for another five years. The simulation during the first five years is the same as illustrated for companies without employee caps. For the second five years of simulation, their employee numbers have been capped to their value after the first five years of simulation. These simulations show that more ambitious targets lead to greater payoffs after periods of growth. They exaggerate the development observed for BaseT (Figure 6-9).

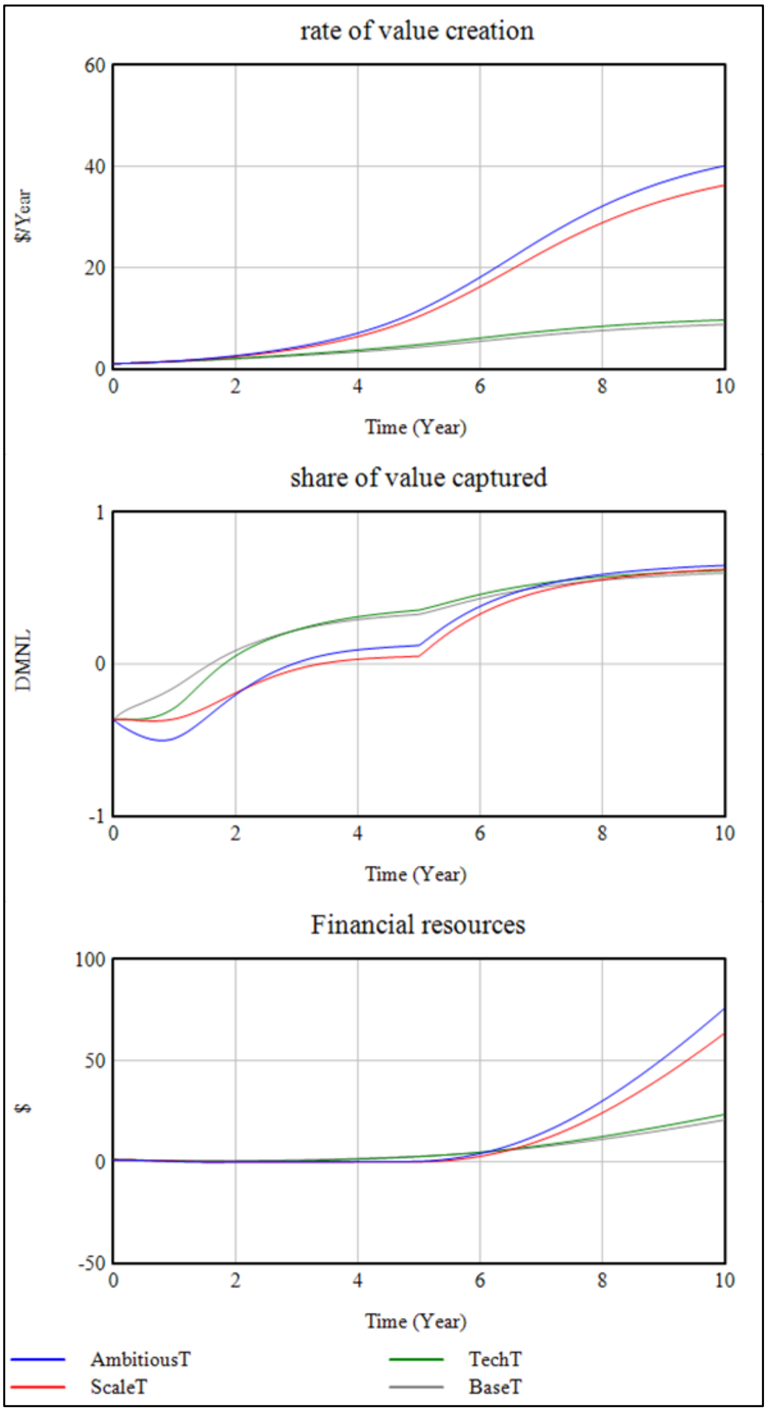


Figure 6-9: Effect of changes to transitioning base case's dominant logic (targets)

Ambitious and customer-focussed targets exaggerate the impact on value creation and capture during the growth period. However, they also exaggerate the benefits to both performance outcomes after the period of growth. Like BaseT, all transition scenarios return to goal-seeking development towards new natural performance levels. However, their ambitious growth targets have increased company sizes to much higher levels during the first five years. Therefore, their natural rate of value creation is also much higher. In addition, these companies benefit from the economies of scale that increase their share of value captured. Because both performance outcomes are higher, AmbitiousT and ScaleT accumulate financial resources much quicker. Thus, while ambitious growth has more severe adverse effects during the period of growth, its payoff after periods of growth is also significantly higher.

6.3.2.2. Different restructuring magnitudes

The transitioning base case and different targets have assumed that ventures maintain the number of employees at the end of the growth period. This has allowed for theoretically relevant demonstrations of the impact of transitions and targets. However, as the simulations in the validation chapter have shown, employee caps are often lower. Ventures introduce lower caps as part of restructuring programs to reduce costs. Striving for realistic simulations, such reductions should be simulated. The scenario set-up below follows the same structure as the transitioning base case. However, they do not assume that the employee numbers at the end of the growth period are the cap. Instead, they simulate reductions in employee numbers at the point of transition. Two scenarios are designed to facilitate this process: a cap of 20% (Reductions20) and of 50% (Reductions50) below the employee numbers at the end of the growth period. The simulations show the expected goal-seeking behaviour in the employee-capped period. However, companies develop towards different natural performance levels. While laying off employees increases the share of value captured quickly, it results in lower levels of value creation in the long term (Figure 6-10). Thus, companies introducing layoffs present another trade-off between value creation and capture.

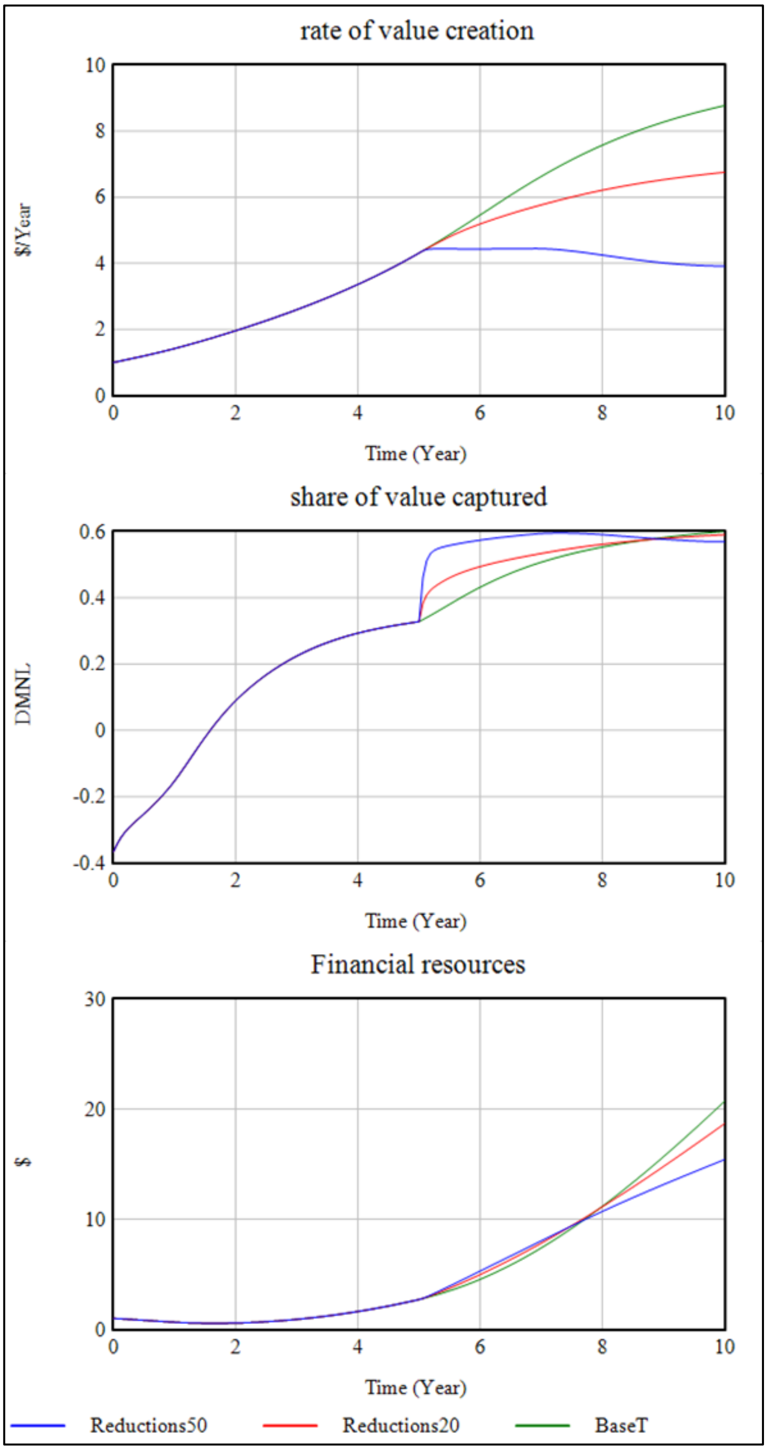


Figure 6-10: Effect of changes to transitioning base case's dominant logic (reductions)

A benefit of reducing rather than maintaining employee numbers after growth periods is a quick increase in the share of value captured. The two scenarios with employee reductions show step-like changes in the share of value captured. The more significant the reduction, the higher the rapid improvement in the share of value captured. Timing differences between losing cost-generating and value-creating resources explain these step-changes. The venture can quickly lay off its employees and reduce its costs. However, it can hold on to value creating resources like the customer base and technological quality that these employees have created before being laid off.

However, the simulations also show that layoffs lead to lower rates of value creation towards which companies develop. Like companies that have grown at higher rates before transitioning, companies that maintain more employees can establish a larger size. On the other hand, companies which lay off employees give up more of their size potential. In all previous simulations, companies have increased their rate of value creation to their natural performance levels. The Reduction50 scenario above shows that companies may also fall towards their natural performance level. For example, rather than filling up its capacity limit, the venture falls towards its capacity limit. After layoffs, its employees could not service all customers appropriately, increasing churn rates and reducing the customer base. The smaller size also affects the share of value captured due to economies of scale in the long term. The companies with lower reductions show a slightly higher share of value captured at the end of the simulation.

6.3.2.3. Different number of growth cycles

Another method to balance value creation and capture might be switching from employee-uncapped to -capped growth states more often. So far, the transition companies only develop through one growth cycle with unconstrained growth in the first five years and employee caps in the second five years. However, managers may increase the number of growth cycles they pursue. Scenarios with two and five growth cycles have been developed to investigate the impact of more regular switches. In 2Cycles, the company switches between dominant logics with and without a cap on employee numbers every two and a half years. In 5Cycles, the company switches dominant logics every year. Both scenarios begin the simulation with a dominant logic without employee caps. The employee caps are set to the number of employees at the end of the previous period without caps. Overall, these different dominant logics show that the positive and negative effects of the cycles depend on when one investigates the ventures (Figure 6-11). Fewer growth cycles have an early advantage in the rate of value creation.

However, more growth cycles lead to higher levels of value creation at the end of the simulation. These outcomes are reversed for the share of value captured, further indicating the trade-offs between value creation and capture. The financial resources as a cumulative performance measure are best for the base case with only one growth cycle. These three elements are discussed below.

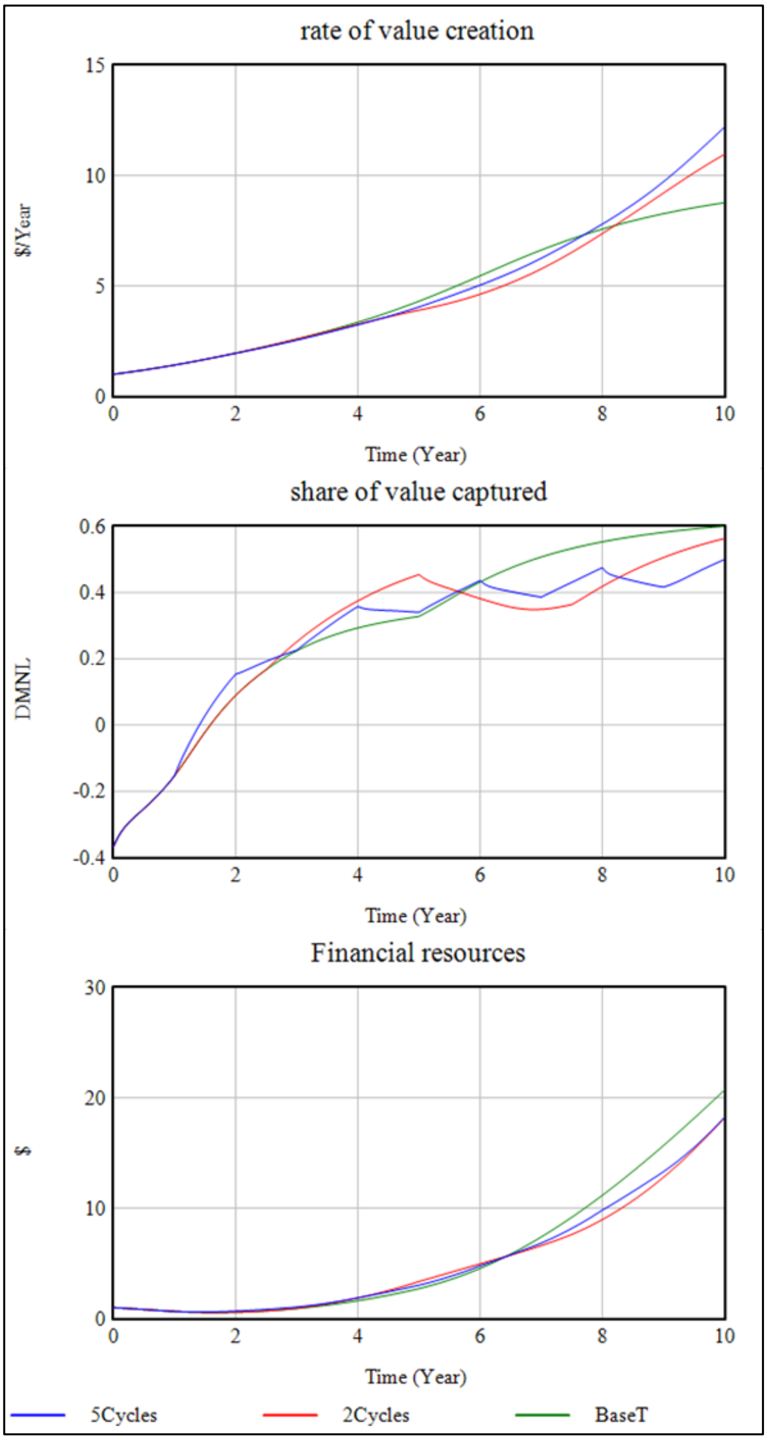


Figure 6-11: Effect of changes to transitioning base case's dominant logic (cycles)

Pursuing fewer growth cycles leads to a higher level in value creation up to about seven and a half years of simulation. This initial outperformance in value creation for fewer growth cycles can easily be explained because the simulation assumes growth for the first five years. The simulations with higher growth cycles assume that the ventures grow without employee caps only for half of that time (2Cycles) or three years (5Cycles). Companies capping their employee numbers can also grow at decreasing rates and are limited to their natural performance levels. Therefore, the high number of growth cycles allows the ventures to scale up to ultimately higher rates of value creation.

While more growth cycles lead to an earlier improvement in the share of value captured, the base case with one growth cycle overtakes them once it stops growing. The theory outlined above can explain these initial improvements in the share of value captured. Growth leads to lower capability levels and thus lower shares of value captured. The company growing for the first five years without employee caps suffers from those lower levels for the entire first five years. The ventures stopping their growth more frequently can improve their share of value captured during the periods in which they cap their employee numbers. However, in the periods in which these companies grow again, their share of value captured falls again. This causes oscillation in performance outcomes with improvements when the ventures cap employee numbers and deterioration when they grow without caps. These adverse effects during uncapped years also explain the lower share of value captured for more growth cycles in the second half of the simulation. Here, the companies with more growth cycles suffer from the adverse effects of growth on the share of value captured. Even in years in which it caps employee numbers, the share of value captured remains below the base case with one growth cycle. In these years, the return to growth periods occurred before all improvements in the share of value captured took place.

The base case with one growth cycle leads to the highest financial resources as a cumulative performance measure. The above illustrations for different growth cycles demonstrate the trade-offs between growth in value creation and the share of value captured. While companies with more growth cycles can increase their share of value captured earlier, they ultimately fall behind. However, they can increase their rate of value creation to higher levels. Due to these mixed results for the individual performance outcomes at different points in time, the financial resources as a cumulative measure of performance indicate the superior approach. Over the ten years of simulation, the company with one growth cycle accumulates the most resources. Taking a longer view might lead to different results, depending on the subsequent actions of companies with more growth cycles. As illustrated in the previous section, their higher rate of value creation might start paying off if they stopped growing. This leads them ultimately to a faster rate of resource accumulation that eventually overtakes the company with only one growth cycle.

6.3.3. Internal improvement for capability development

Another route to maximise the payoff after growth periods concerns internal improvements by affecting variables related to capability development. The same scenarios affecting training times, new employee capabilities, and employee turnover are utilised to investigate the impact of internal improvements on BaseT. These simulations show the need to pursue internal improvements continuously throughout both types of dominant logic. Improvements lead to minor variations in the rate of value creation, improved shares of value captured, and accelerated financial resources accumulation (Figure 6-12).

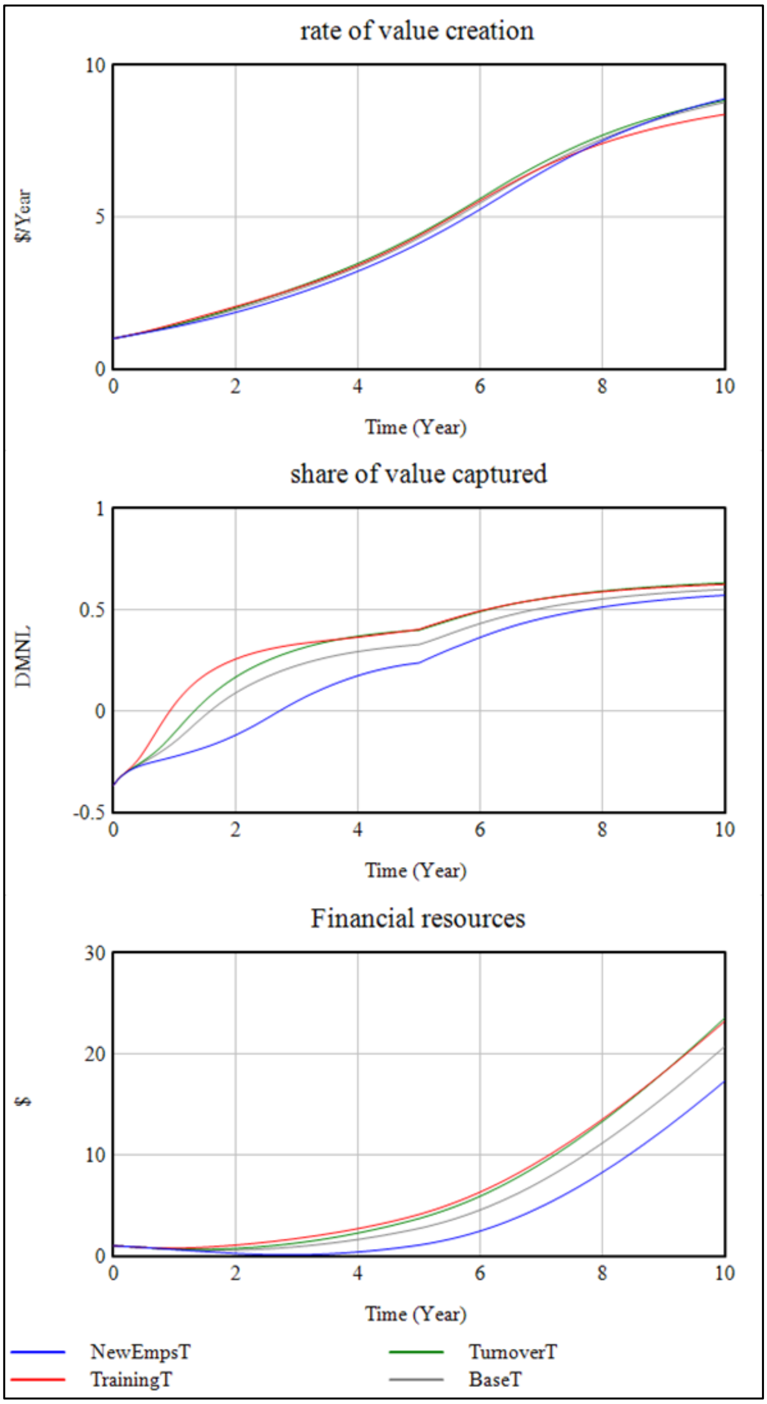


Figure 6-12: Effect of changes to transitioning base case's capability development

The transitioning base case is a combination of both dominant logics one after another. Therefore, the benefits of internal improvements can be explained by the benefits during the two individual dominant logics. During the first five years, the transitioning base case is growing without employee caps. It thus benefits from internal improvements by achieving its growth and improvement targets with fewer employees. These improvements increase the share of value captured at similar rates of value creation. During the second five years, the transitioning case caps its employee numbers. It now benefits from its capped employees achieving more output in their respective activities. Here, the venture benefits from an increased rate of value creation and lower costs when expressed as a fraction of value creation. Combined, those continuous improvements throughout the periods lead to lower falls in financial resources. They reduce the risk of bankruptcy during growth and accelerate the accumulation of financial resources in the long term.

6.4. Contextual influences and robustness

The above section has illustrated that digital ventures with employee caps experience goal-seeking performance development for their rate of value creation and share of value captured. The management can alter the level towards which their companies develop through the variables available in the model. These variables are targets expressed in the dominant logic and internal improvements affecting capability development. However, ventures with employee caps cannot diverge from a goal-seeking pattern. They can only grow their value creation exponentially by eliminating caps on employee numbers. The simulations have shown that they do so at the expense of the share of value captured. The higher the growth rates targeted by the venture, the lower the share of value captured. While companies can soften the negative impact on the share of value captured through internal improvements, their performance still lags behind companies that cap their employee numbers. Thus, companies may introduce employee caps after periods of growth. Ambitious growth paired with internal improvements pays off especially once the company stops increasing its headcount. To pursue this enquiry, the simulations used two types of influences from the model development chapters. Firstly, the different types of dominant logic, which the model conceptualisation chapter outlined, and secondly, the variables for managerial influences regarding targets and capability development which the model formalisation chapter uncovered. However, model formalisation has also identified contextual influences in the business model design and external environment. The management determines these when launching their ventures and before growing its business. This section confirms the robustness of the above performance development patterns in different environments and for different business model designs. The section further investigates the influences of these contextual factors on performance development in employee-capped and employee-uncapped companies[28].

6.4.1. Different environmental conditions

The model development chapters have identified contextual factors in the external environment that affect performance outcomes directly or indirectly. The development of the model on its detailed, formal level has grouped these environmental influences into four stakeholder groups: customers and users, inputs providers, competitors and providers of substitute products, and providers of complementary products. So far, the model has assumed that exogenous variables related to these environmental groups remain constant at the base case level introduced at the beginning of this chapter. The following simulations investigate how changes in the environment affect the development of value creation and capture. They confirm and assess the performance development in different stable and dynamically changing environments.

6.4.1.1. Stable environments

In strategic management, the industry-structure approach has investigated the impact of environmental conditions on the performance of companies (Porter, 1985, 1991). In growth paths theory, entrepreneurs select their environment by deciding which product to launch in which market. Thereby, they select – although often unconsciously – their target customers. With these customers, entrepreneurs also select the constellation of suppliers, competitors, and complementary products that determine the attractiveness of an environment (Garnsey, 1998; Garnsey and Heffernan, 2005). The first contextual scenarios thus focus on simulating differently attractive environments (Table 6-3). Under *favourable* environmental conditions, the venture was able to identify and target

[28] This section does not test the performance development of transitioning companies because they combine the capped and uncapped scenario developments (see Section 6.3).

superior customer segments and enter a market in which it can link its product to complementary products. The model reflects these conditions through a higher maximum usage intensity of customers and a higher rate of feature adoption. Customers also have a longer lifetime, acquire new customers for the venture by recommending its product (i.e. WoM), and the quality of complementary products is higher. The venture faces suppliers with higher bargaining power, stronger competition, and more competitive market conditions in the *hostile* environment. The parameters reflect these conditions through higher input costs and more competitors with superior products.

Table 6-3: Changes to reflect differently attractive stable environments

<table>
<tr><th>Variables</th><th>Hostile</th><th>Base</th><th>Favourable</th></tr>
<tr><td>Maximum customer usage intensity</td><td colspan="2">1.5</td><td>2</td></tr>
<tr><td>Standard rate of adoption</td><td colspan="2">1</td><td>2</td></tr>
<tr><td>Standard customer lifetime</td><td colspan="2">5</td><td>8</td></tr>
<tr><td>Rate of customer acquisition per customer</td><td colspan="2">0%</td><td>10%</td></tr>
<tr><td>Quality of complementary products</td><td colspan="2">1</td><td>2</td></tr>
<tr><td>Costs of each type of input</td><td>30%</td><td colspan="2">25%</td></tr>
<tr><td>Strength of competitors and substitutes</td><td>1.5</td><td colspan="2">1</td></tr>
<tr><td>Number of competitors and substitutes</td><td>1</td><td colspan="2">0.5</td></tr>
</table>

While the performance outcomes improve in the favourable environment, the hostile environment erodes performance (Figure 6-13). These findings apply to ventures that cap (top row) and do not cap employee numbers (bottom row). While some variables have shifted the natural performance levels towards which a venture develops, other influences have also shifted the initial level. These simulations confirm the behaviours and patterns identified in the previous section and validate them across differently attractive environments.

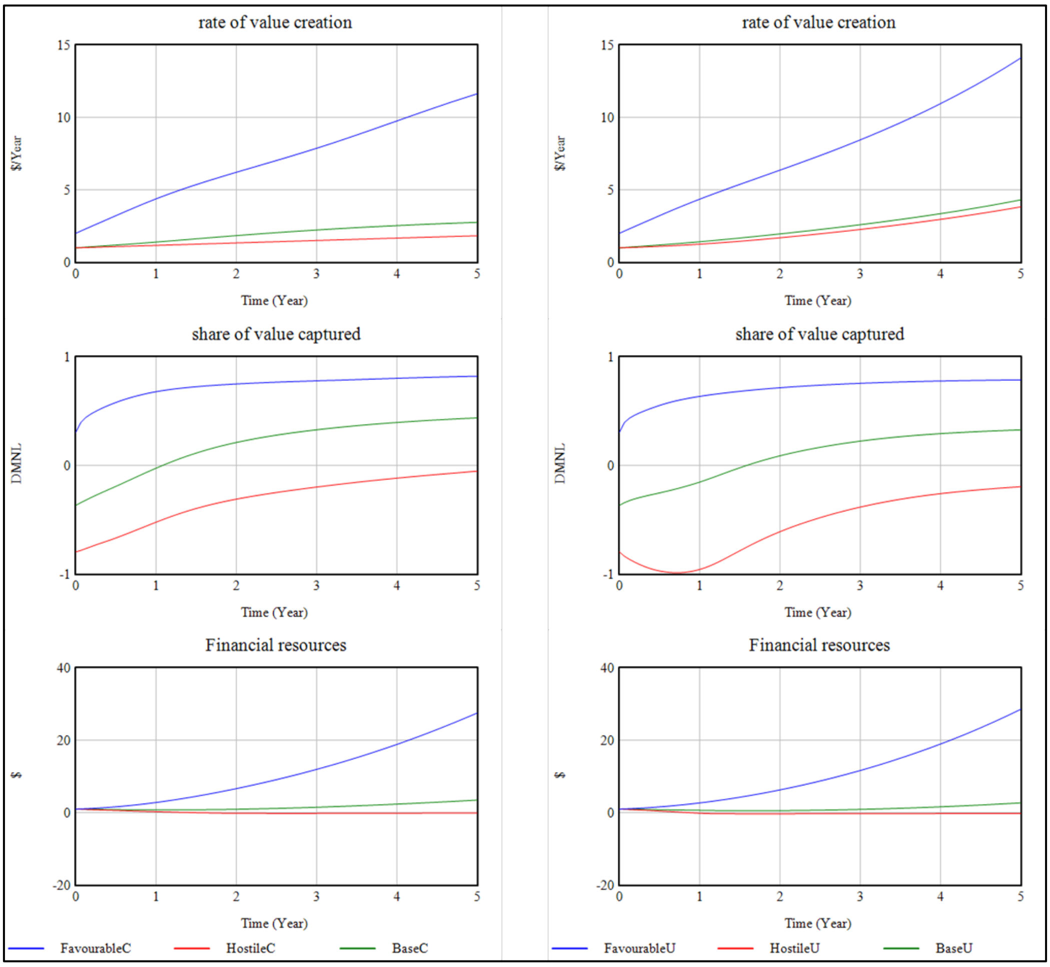


Figure 6-13: Effect of stable environment conditions

The simulations of the differently attractive environments show that favourable environmental conditions improve performance for employee-capped and -uncapped digital ventures. Hostile environmental conditions have the opposite effect. Thereby, performance development maintains the patterns identified in the previous sections. The scenarios thus validate the findings across differently attractive environments. The employee-capped company develops towards higher levels of value creation and capture under favourable environmental conditions. It develops towards lower levels in hostile environments. Similarly, the employee-uncapped company exhibits faster growth in value creation and higher shares of value captured under favourable conditions. Its growth in value creation and the share of value captured are lower in hostile environments. Due to superior performance in favourable environments, financial resources accumulate faster. They deplete quicker or rise slower in hostile environments. Especially in the hostile environment, the company's financial resources fall below zero. This fall indicates that these companies have gone bankrupt before the end of the 5-year simulation. Injecting more capital into the ventures under these hostile conditions would have allowed them to operate longer without going bankrupt. However, because the companies never develop an ability to capture value, they will ultimately fail and just burn through more capital. Digital ventures should avoid competitive markets and strong competitors to avoid such hostile conditions. They should also rely on low-cost inputs for their activities and link their product to established complementary offers. To further benefit from favourable market conditions that improve performance outcomes, digital ventures should strive to select favourable environments. They should target customers and users who make intensive use of their product, quickly adopt new features, and link their product to established complementary offers.

Tracing the impact of these different environmental conditions in the favourable and hostile scenario on performance outcomes reveals two different types of influences. Some variables that affect performance outcomes directly shift the curves by lifting their initial and maximum levels. Such variables include, for example, input costs. In addition to such direct environmental influences, performance outcomes depend on the resources of the venture. Environmental factors affecting resource stock accumulation cause a change in the maximum level and development speed towards it. However, they do not change the initial performance level. For example, a higher customer lifetime reduces the number of customers lost every year. Ventures targeting customers with higher lifetimes can thus increase their customer base quicker and to a higher level. This improved targeting increases their natural performance level and the speed of development towards it. Variables related to competition combine both types of influences. They affect performance outcomes directly and via resource stock accumulation. With higher levels of competition, the venture captured less value from customers while its customer base also grows slower.

6.4.1.2. Dynamics environments

A critical strength of simulation modelling as a research tool is eliminating confounding factors to isolate mechanisms of interest (Davis *et al.*, 2007; Harrison *et al.*, 2007). For example, the model isolates and investigates how performance would develop based on internal changes while holding the environment constant and assuming it is perfectly stable. The previous sections' simulations and the above favourable and hostile scenarios assume such constant and stable environments. While these are theoretically relevant to identifying internal changes affecting performance outcomes, business environments are dynamically changing. Therefore, two scenarios with changing environments have also been developed to increase the realism of simulations (Table 6-4). In the *improving* environment, customer variables and complementary qualities improve from their base case to the favourable levels over time. This scenario represents environments in which the target customers become increasingly familiar with digital technologies, for example, by having seen similar technologies and applications before. The scenario reflects that providers of complementary products launch and improve their complements over time. In the *worsening* environment, competition and input costs increase over time to hostile levels. This scenario reflects environments in which a venture has discovered an initially attractive environment. However, over time, this attractiveness also entices competitors to enter the market and suppliers to raise their prices to capitalise on the venture's success. The model reflects these improving and worsening conditions by setting the initial and end value of the variables. The initial values are the base case values introduced at the beginning of this chapter. The end values are the favourable and hostile scenario values illustrated above. The model uses linear interpolation between these initial and end values.

Table 6-4: Changes to reflect different environmental dynamics[29]

<table>
<tr><th>Variables</th><th>Hostile</th><th>Base</th><th>Favourable</th></tr>
<tr><td>Maximum customer usage intensity</td><td colspan="2">1.5</td><td>1.5 -> 2</td></tr>
<tr><td>Standard rate of adoption</td><td colspan="2">1</td><td>1 -> 2</td></tr>
<tr><td>Standard customer lifetime</td><td colspan="2">5</td><td>5 -> 8</td></tr>
<tr><td>Rate of customer acquisition per customer</td><td colspan="2">0%</td><td>0 -> 10%</td></tr>
<tr><td>Quality of complementary products</td><td colspan="2">1</td><td>1 -> 2</td></tr>
<tr><td>Costs of each type of input</td><td>25% -> 30%</td><td colspan="2">25%</td></tr>
</table>

[29] For improving and worsening conditions, the left and right values reflect, respectively, the value at the beginning and end of the simulation. For example, the term "5 -> 8" for customer lifetime represents that the customer lifetime is five years at the beginning of the simulation. At the end of the simulation, it is eight years. During the five years of simulation, the model interpolates between these two values linearly. For example, after one year of simulation, the customer lifetime was 5.6 years.

Strength of competitors and substitutes	1 -> 1.5	1
Number of competitors and substitutes	0.5 -> 1	0.5

In improving and worsening environmental conditions, the behavioural patterns for companies with and without caps on employee numbers change (Figure 6-14). Improving conditions lead to, for example, exponential growth in value creation even for companies with caps on employee numbers. Worsening conditions lead to a deterioration in value creation and capture over time. However, while these developments look different from the patterns discussed in the chapter so far, they can be explained through them.

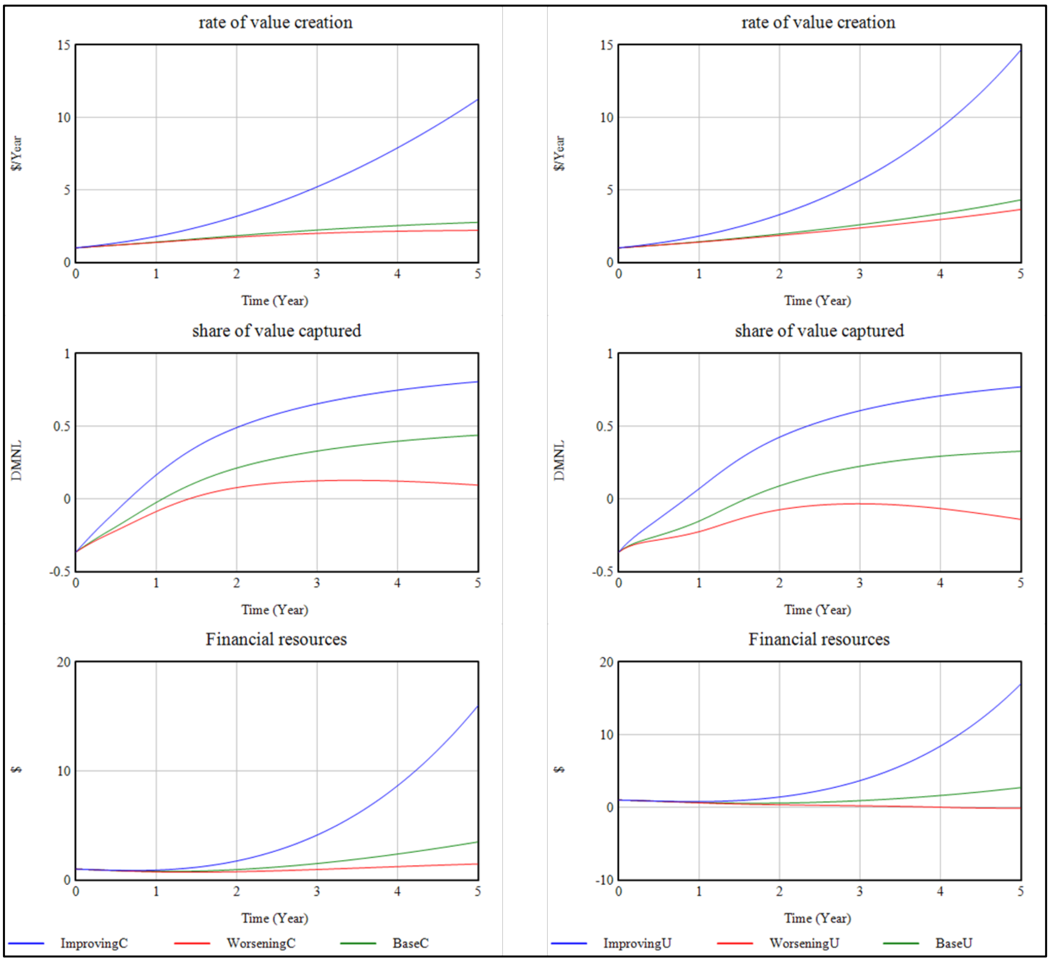


Figure 6-14: Effect of environmental dynamics

In changing environments, such as the improving and worsening scenario, the patterns of performance development seem fundamentally altered. The improving environment leads to exponential growth in value creation in companies that cap and do not cap their employee numbers. Improving environmental conditions prevent the balancing feedback loops causing goal-seeking development from becoming dominant. For example, at a constant maximum usage intensity, each customer will eventually develop to this maximum. However, with this maximum level increasing in the improving scenario, customers can consistently increase their usage intensity further. In the worsening environment, the rate of value creation grows at a lower rate for the employee-uncapped company because the management continuously overestimates its employees' productivity. All other performance outcomes peak about halfway through the simulation before deteriorating again or about remaining stable. The venture's productivity improvements (and higher inputs in WorseningU) allow it to initially improve the rate at which it acquires customers and improves its technology. However, when no further productivity improvements are possible, the venture loses against ever-improving competitors and increasing prices for input resources. Like the hostile scenario, companies in the worsening scenarios may not develop an ability to capture value and go bankrupt. Additional capital would have expanded the lifetime of these ventures. However, they will continue to burn through their capital and never turn profitable as their share of value captured continues to erode.

While these performance development patterns look different from those identified in this chapter already, the established patterns can explain and account for them. One can separate the dynamically changing environments into a series of different environments. The scenario set-up included beginning and end values for inputs with linear interpolation between these values. One can also interpret this interpolation as creating a unique environment for every step of the simulation. As the investigation of differently attractive but stable environments shows, each of these different environments has a different performance level. These levels follow the patterns outlined throughout this chapter. Thus, the improving and worsening scenario for employee-capped companies reflects goal-seeking development towards ever-improving and ever-decreasing natural performance levels. Similarly, the two scenarios for employee-uncapped companies reflect a series of developments towards ever-increasing or ever-decreasing shares of value captured.

It is also to note that performance in the improving and favourable scenarios and the hostile and worsening scenarios will converge once the environmental conditions are constant. Comparing the graphs in the two subsubsections, readers can identify that the value creation and the share of value captured graphs of the favourable and improving scenarios move towards one another. The same applies to the worsening and hostile scenarios. Thus, if the final environment is the same, the performance of companies with the same characteristics will eventually be the same. However, due to initial differences in value creation and capture, financial resources will maintain a difference. When performance outcomes have converged, the rate of cash generation of both companies is equal. However, because of superior value creation and capture in the favourable and worsening environments, financial resources get a head start compared to the improving or hostile environments. Thus, companies should seek to identify initially attractive environments rather than striving to make an industry attractive. They should also strive to slow down adverse environmental changes such as increasing competition or input costs.

6.4.2. Different business model designs

Besides the environment, the business model design has been identified as a contextual element determined before digital ventures scale up their product. A range of value drivers, mechanisms through which digital ventures create value for customers and users, have been identified during model formalisation. Similarly, the model includes variables that convert capabilities from their qualitative, soft scales between zero and one to impacts on the model's hard variables. As the model inputs for the base case at the beginning of this chapter illustrate, simulations assume the business model design of a SaaS company. Effect sizes have been set to ensure simulations are not affected by surges in hiring or layoffs just after the beginning of the simulation. However, companies may design different business models, which may impact performance development. Thus, the development patterns observed in this chapter require validation regarding active value drivers and transformational effect sizes. This subsection confirms the robustness of development patterns regarding these two contextual elements. It provides further insight into the development of value creation and capture for different business model designs.

6.4.2.1. Business models with network effects

Model formalisation identified different value drivers for digital ventures (Chapter 4). The model validation chapter (Chapter 5) illustrated how companies might use these value drivers in practice. It distinguished and tested two different types of business models. Firstly, SaaS business models (Alpha and Beta) that rely on their technology as a driver of use value creation. Secondly, digital ventures which also rely on network effects to create customer value (Gamma and Delta). The detailed model development has further distinguished direct, indirect, positive, and negative effects. So far, the simulations in this chapter have assumed the business model of a SaaS venture that relies solely on its technological quality. Thus, the robustness of identified development patterns needs to be confirmed for network effects. Two scenarios have been developed and compared to the base case with a SaaS business model. In both new scenarios, the ventures distinguish between paying customers and non-paying users (Table 6-5). The first scenario is set up to investigate a social *network*'s performance development, in which value is created for users based on positive direct network effects. Customers who pay for the product, for example, advertisers, benefit through indirect network effects from the user base. However, there are negative direct network effects between customers as more advertisers increase the competition for users on the platform. The second scenario represents a *marketplace* that brings buyers and sellers together. Through positive indirect network effects, both groups benefit from one another. However, they are adversely affected by negative direct network effects.

Table 6-5: Changes to reflect business models with network effects

Variables	Base	Network	Marketplace
Initial customer base	1	.5	.5
Initial user base	0	.5	.5
Target user growth rate	0	25%	25%
Customer direct network effect settings	0	-1	-1
Customer indirect network effect settings	0	1	1
User direct network effect settings	0	1	-1
User indirect network effect settings	0	0	1
effect of competence on ability to acquire users	0	1.5	1.5
effect of competence on ability to service users	0	2	2

The changing business models employing varying value drivers show the same development patterns illustrated throughout this chapter (Figure 6-15). The employee-capped scenarios (top row) show goal-seeking developments of performance outcomes. The employee-uncapped companies (bottom row) show exponential growth in value creation at the expense of the share of value captured. However, differences in the growth rates and shares towards which the performance outcomes develop can be observed, which are explained below.

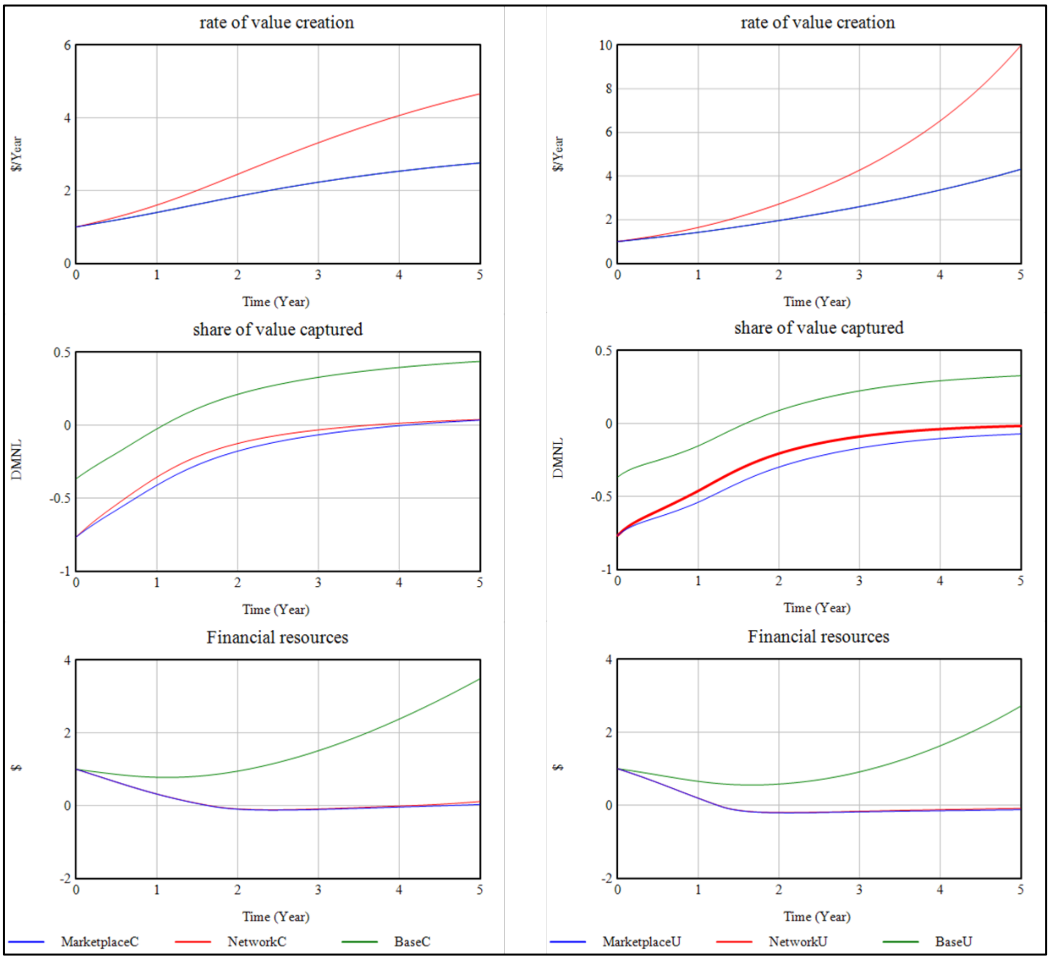


Figure 6-15: Effect of business models with network effects

A first difference regarding the business model design is the increase in the rate of value creation for social networks that employ mostly positive network effects. The marketplaces and base cases do not exhibit this increase in the rate of value creation. The increased rate of value creation for the network is explained by employing more positive than negative network effects. Thereby increasing user and customer bases affect value creation in two ways. The venture creates value for more users and customers and it increases the value created per user and customer. This second effect is missing in SaaS and marketplace business models. While customers in a SaaS business model do not directly benefit from other customers using the platform, positive and negative network effects cancel out for marketplaces. A second difference regards the lower share of value captured for companies that serve customers and users. The lower share of value captured for networks and marketplaces can be explained by these business models creating value for users and customers. However, they only capture value from customers while users receive the product for free.

6.4.2.2. *Business models with different efficiency levels*

Business models also differ regarding the variables that convert capabilities from their soft, qualitative scale to a hard impact on the system. The effect sizes of the base case were set to balance the venture and avoid surges in hiring and layoffs at the beginning of the simulation. In reality, these effect sizes represent an employee's output with fully developed capabilities and thus the best-practice throughput of activities (Warren, 2002). However, digital ventures may design their activities differently and, therefore, have different best-practice throughputs. Three scenarios investigate the impact of changing these effect sizes (Table 6-6). Effect sizes have been lowered by 50% and 20% and increased by 20%.

Table 6-6: Changes to reflect different productivity levels

Variables	Lower50	Lower20	Base	Higher20
effect of competence on ability to develop technology	0.2	0.32	0.4	0.48
effect of competence on ability to maintain technology	2	3.2	4	4.80
effect of competence on ability to acquire customers	0.75	1.2	1.5	1.8
effect of competence on ability to service customers	1	1.6	2	2.4
effect of competence on ability to manage the firm	4.5	7.2	9	10.8

The venture with higher effect sizes maintains the development patterns of value creation and capture observed throughout this chapter (Figure 6-16). It develops in a goal-seeking manner towards higher natural performance levels when capping its employee numbers. It also exhibits similar growth in value creation but develops towards an improved share of value capture when it does not cap employee numbers. The venture with 20% lower effect sizes also follows these patterns but with development towards lower performance outcomes. However, the venture with a 50% reduction in effects sizes diverges from these development patterns. Its rate of value creation develops towards zero, while its share of value captured falls throughout the simulation and does not seem to develop towards a specific value in a goal-seeking manner. While this development pattern looks different on a superficial level, it can be explained through the mechanisms outlined throughout this chapter.

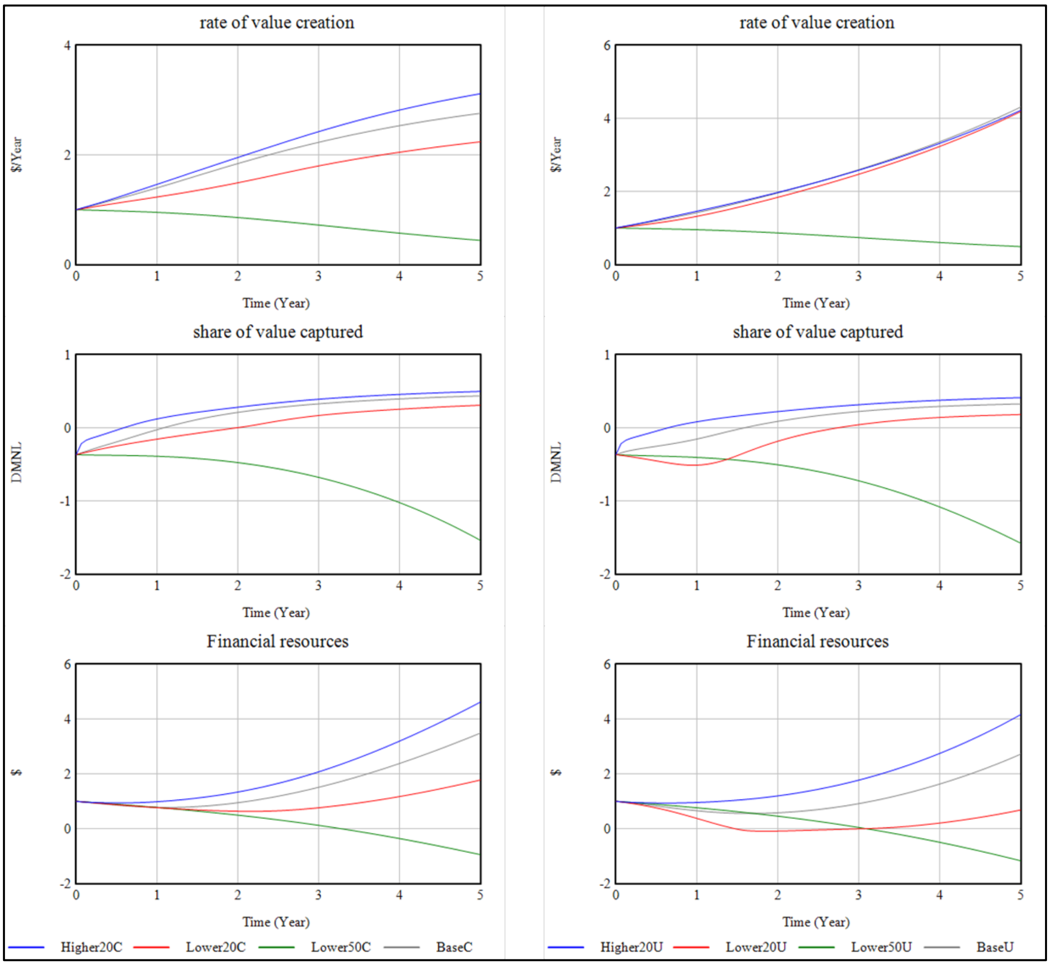


Figure 6-16: Effect of business model's efficiency levels

Ventures with higher effect sizes will develop towards higher natural performance levels for both outcomes when capping their employee numbers. They develop towards a higher level of the share of value captured when not capping their employee headcount. These patterns are like those identified when investigating capability levels in the previous sections. For employee-capped companies, the same number of employees can achieve more. They thus increase value creation and the share of value captured at constant absolute costs. For employee-uncapped companies, fewer employees can achieve the venture's targets. Thus, the venture increases its share of value captured at a similar rate of value creation. In either case, the improved rate of value creation and share of value captured leads to a quicker financial resource accumulation.

However, with lower capabilities, the rate of value creation and share of value captured may deteriorate over time for employee-capped and -uncapped companies. Under conditions in which the management is firefighting and has no time to implement growth and improvement plans, the rate of value creation falls. Superficially, this looks like a performance development pattern different from those discussed throughout this chapter. However, like different patterns in dynamic environments, the deterioration can be fully explained by the patterns already discussed in this chapter. For example, goal-seeking patterns for both performance outcomes were expected for employee-capped companies. However, it has not been stipulated that companies improve towards their natural performance levels. Just as in worsening environments, company performance may also deteriorate to their natural level. Similarly, companies with layoffs may fall towards their natural rate of value creation. With smaller effect sizes like in the above scenario, the companies may have a natural rate of value creation of zero. This indicates that the venture has developed a business model that is not sustainable and will never turn profitable (even when competition is not increasing). In such cases, the development in the rate of value creation is still goal-seeking but deteriorates to its goal of zero rather than improving towards a higher rate. This development towards zero also explains the development of the share of value captured. As outlined in the first section of this chapter, employee-capped companies have constant absolute costs. Expressed as the fraction of an increasing rate of value creation, the share of value captured increases too. However, the constant amount of costs increases when expressed as a fraction of decreasing value creation. Thus, this fall is consistent with the theory outlined throughout this chapter and presents a special case of it.

6.5. Implications to the case firms

The simulations in this Chapter elaborate on development patterns observed in the case companies. They explain the development patterns of the case companies without interference from noise in data like the sale of assets. Moreover, they provide a basis to evaluate companies' different policies regarding their goals, contextual factors, and restructuring activities.

The simulations show that companies are right to pursue growth and technological improvements simultaneously. As the simulation of different targets shows, the combination is superior for growing companies. On the one hand, technology improvements increase the share of value captured. On the other hand, ventures can spread development costs and amortisation over more customers. Therefore, for example, Alpha is correct to start pursuing such improvements in its final growth state. However, it should have pursued improvements throughout the years as Beta, Gamma, and Delta did.

The companies are also correct to transition away from dominant logics without caps on employee numbers. Instead, introducing caps on employee numbers allows the processes that improve value creation and capture to improve both performance outcomes simultaneously. The simulations of such transitions show that they accelerate financial resources accumulation. While growth will slow down, this transition may allow the companies to develop an ability to capture value. Alpha is a primary example of this development. Once it transitions, its marketing and selling employees remain nearly constant for more than four years. During this time, its share of value captured reaches its natural performance level and turns nearly positive, while it takes further action to improve its value creation (see below).

However, unless necessary to sustain themselves, companies should not restructure. Instead, they should have maintained their employee numbers. The simulation of restructuring shows that restructuring can quickly improve the share of value capture. However, companies do so at the expense of their long-term performance. Their lower inputs may not allow the companies to maintain their established size. Therefore, value creation may decrease over time, and they may give up established economies of scale. This outlook raises the question, why executives felt the need for restructuring. An explanation might be that there might not have been enough time for the dynamic processes to improve the share of value captured. Executives might have felt that the company would go bankrupt if it did not quickly improve profitability, i.e. the share of value captured. Executives thus require more foresight. Rather than growing and giving up a part of their venture’s size potential, they should have foreseen financial difficulties and started transitioning earlier without restructuring. The model developed in this thesis might help future managers and entrepreneurs to do so. They may use the model to approximate company developments and act earlier. The model may help them to measure performance in the moment without waiting for accounting reporting cycles (Subsubsection 4.1.5).

The case companies should also take additional actions to develop an ability to capture value. An example of such actions is Alpha. The company has taken additional steps to optimise its business model by switching market segments. They identified a superior customer segment during its growth process. The company has done well to optimise its contextual factors. It has grown its value creation and improved its share of value captured significantly, thereby nearly reaching an ability to capture value, despite lowering its target customer growth rate. However, simulations show that Alpha should have pursued these more attractive customers from the outset. Thereby, it would not have spent time and money on acquiring a less attractive customer segment. Nevertheless, Alpha excels in optimising contextual factors compared to the other companies. Beta's, Gamma's, and Delta's developments, even with caps on employee numbers, are worrying because restructuring has not allowed the company to develop an ability to capture value. Instead, they remain loss-making. These losses indicate that the companies have not optimised the contextual factors that determine the trajectory of their performance development. Therefore, their natural share of value captured toward which they develop is negative, and the companies can only survive through external funding. Managers and entrepreneurs of Beta and Gamma might have sold their respective companies due to this incapacity to develop an ability to capture value. Delta, which remains independent, needs to select a more attractive environment, develop a more efficient business model, and pursue internal improvements to develop superior capabilities. These are requirements for the development of an ability to capture value sustaining the venture.

Chapter 7: Discussion

This thesis aims to develop an understanding of the requirements and priorities allowing digital ventures to develop an ability to capture value while growing their value creation. This discussion first reviews the influences on value creation and capture. It then proposes a framework outlining the main propositions for digital ventures' ability to grow their value creation and capture value. The introduction of this thesis has proposed two research questions regarding the development and relationships of value creation and capture for digital ventures. The final two sections of this discussion illustrate the implications of the previous chapters for the two research questions, compare the findings to previous research, outline implications for theory and practice, and link them to the framework's elements and relationships.

7.1. Influences on value creation and capture

This thesis has synthesised growth paths theory and dynamic states theory, adapted the theories for the context of digital ventures, and focused them on value creation and capture. Thereby, this thesis captures the development of companies and their performance comprehensively.

The developed model highlights that performance outcomes, resources, and capabilities change continuously. At any point in time, value creation and capture depend on the venture's resources and external environment (Sections 3.2.1, 4.1, 4.2). These resources themselves continuously change through activities and capabilities (Section 3.2.2). The formal model considers this continuous resource accumulation in separate subsystems. In the technology development subsystems, the venture's technological quality improves along the technology s-curve (Section 4.3). In the customer and user subsystem, the customer and user bases develop based on customer and user acquisition and churn (Section 4.4). In the firm management subsystem, the venture's human resources and capital assets are altered to provide the means to achieve the venture's growth and improvement goals (Section 4.5). Technology development, marketing and servicing customers and users, and firm management require employees and depend on their capabilities. These capabilities continuously improve through learning and deteriorate with new hiring (Section 3.2.3). Thereby, this thesis reflects relationships considered in the literature on value creation and capture (Teece, 1986; Lepak, Smith and Taylor, 2007), the resource-based view (Grant, 1996; Amit and Zott, 2001), the industry-structure approach (Porter, 1985; Zott and Amit, 2010), and capability development (Slater, 1980; Dosi, Nelson and Winter, 2000). Bringing these relationships together, this thesis can reflect the continuous growth process illustrated in growth paths theory, particularly its resource and capability accumulation (Garnsey, 1998; Stam and Garnsey, 2006). The continuous changes in value creation, capture, and resources can also be observed for case companies and during scenarios simulations. Within a growth state, all case companies show continuously changing performance outcomes and resources during model testing (Chapter 5). Performance outcomes and financial resources also change dynamically during scenario simulations (Chapter 6).

These continuous development processes are affected by contextual influences regarding the environment, business model design, capability development, and the management's dominant logic (Section 3.3). The detailed, formal version of the model considers exogenous variables regarding each of those elements in its subsystems (Chapter 4). They reflect the discontinuous nature of the growth process captured in dynamic states theory (Levie and Lichtenstein, 2010; Brown and Mawson, 2013). Thereby, the model can reflect that some variables remain constant during one or more growth states and change with transitions between states. The punctuated changes in these variables when transitioning between growth states have been observed and confirmed for case companies (Chapter 5). Simulating growth states and transitions has shown that these variables, through their impact on feedback loops, steer the venture's resource and capability accumulation and thereby alter its value creation and capture development (Chapter 6).

7.2. Implications for the ability of digital ventures to growth value creation and capture value

Figure 7-1 reflects the implications of the model's structure and behaviour for digital ventures' growth in value creation and ability to capture value. It distinguishes between two types of growth states: scaling up and exploiting size. These states differ regarding a contextual influence reflecting a venture's growth state and the behaviour of performance outcomes. On the one hand, companies in the scaling up state employ a dominant logic reflecting their willingness to hire more employees to achieve their growth and improvement goals. On the other hand, companies without that willingness exploit their current size. As outlined above, these two types of dominant logic and growth states affect the continuous change among business model elements and performance outcomes. While scaling up, ventures experience exponential growth in value creation. While exploiting size, they exhibit goal-seeking development in value creation. In both growth states, the share of value captured develops in a goal-seeking manner.

However, everything else being equal, companies scaling up develop towards lower shares of value captured. Moreover, the higher the targeted growth rate, the lower the share of value capture. Thus, digital ventures need to prioritise carefully between growth in value creation and their ability to capture value. Companies wanting to bootstrap need to carefully balance growth rates and their ability to capture value by reducing growth goals to maintain a positive share of value captured. If growth rates are so high that companies lose resources during the growth process, they need to raise venture capital. Theory points to a third type of scaling up, acquisitive growth (Lockett, Wiklund and Davidsson, 2007; Penrose, 2009). This thesis has not considered acquisitions, presenting an opportunity for future research. Digital ventures exploiting their current size may also develop towards different value creation and capture levels. For example, mature ventures that have previously scaled up developed economies of scale. These allow them to develop towards higher value creation and capture levels than lifestyle companies that have not previously scaled up. Lastly, restructuring ventures reduce their employee numbers after scaling up and so can quickly develop an ability to capture value. However, they do so at the expense of their long-term value creation and capture.

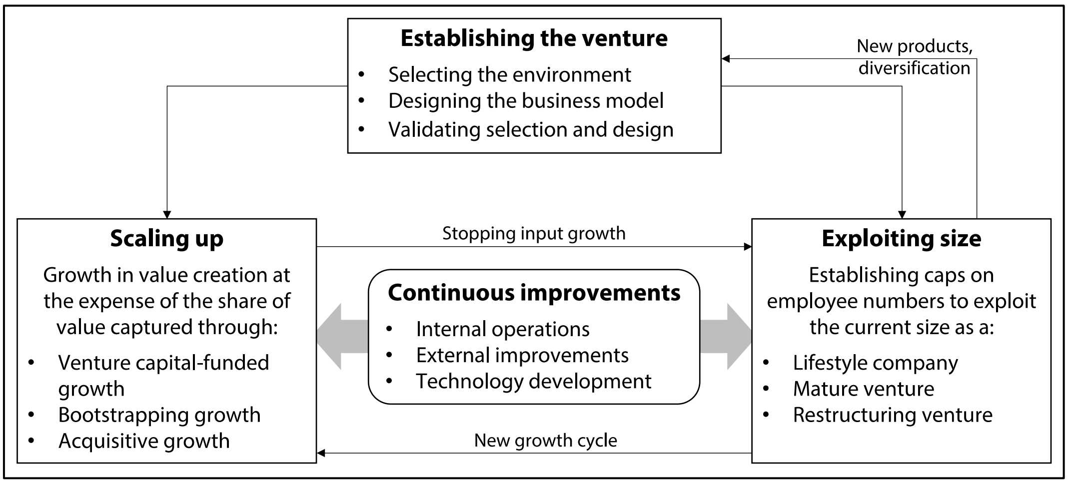


Figure 7-1: Growth process framework

Besides growth targets and their size, the other contextual factors affect a digital venture's rate of value creation and capture. These factors – regarding the venture's environment, business model design, capability development, and managerial targets – determine the trajectories of development patterns in either growth state. To optimise the development of value creation and capture, digital ventures may thus alter those factors. They present the requirements to grow value creation and develop an ability to capture value. When exploiting their size, digital ventures can create the conditions for ultimately higher rates of value creation and capture through these contextual factors. When scaling up, digital ventures can optimise them to lower the adverse effect of growth on value capture and do better at both outcomes simultaneously. However, environmental and business model design factors may present a challenge for reversal. Striving to grow in an unsuitable environment or with an unsuitable business model may drain resources and create lock-in and technological debt (Marmer *et al.*, 2011; Marion *et al.*, 2015; Ramadan *et al.*, 2016; Quinones, 2017; Zaheer *et al.*, 2019; Zaheer, Breyer and Dumay, 2019). Therefore, companies should get these two contextual factors right when establishing the firm and before progressing to one of the other two growth states. On the other hand, digital ventures can develop their internal operations, parts of their environment, and technology when operating. They should thus pursue these improvements continuously to further optimise performance outcomes.

The developed framework provides a growth process framework for managers and entrepreneurs. They may develop their ventures through its three stages iteratively while pursuing continuous improvements. Thereby, it avoids the criticism of OLC stage models and builds on and expands contemporary growth process theories. The framework does not assume that companies develop through these states in a particular order. Instead, companies may stay in a state or progress through them even circularly. For example, companies may return to the establishment state by diversifying and introducing new products, which have not been investigated in this thesis and present another area for future research. Moreover, the framework acknowledges that some activities should be pursued regardless of the growth state. Through these two characteristics, the framework addresses common criticism on organisational life-cycle theory (see Davidsson, Achtenhagen and Naldi, 2010). The framework also adds to growth process theories by aligning growth states with performance development patterns regarding value creation and capture. Thereby, the framework captures a comprehensive theory of growth that connects state characteristics with size changes (Penrose, 2009), while adding value capture as an additional performance outcome. This framework is valuable for practitioners because it illustrates the development patterns of their venture's performance in each state. It captures the answers to the two research questions of this thesis. These answers are reviewed below, linked to the framework and the previous chapters and compared to existing literature, with further implications for theory and practice identified.

7.3. How do value creation and capture develop for digital ventures?

This thesis has simulated the System Dynamics model reflecting the above influences on value creation and capture. Different scenarios have been created and evaluated to reveal the drivers of diverse performance development paths. Reviewing these different paths illustrates that the two different types of dominant logic determine development patterns, while contextual variables determine the trajectories within a pattern. The two subsections below review the findings leading to these two elements, answering how value creation and capture develop for digital ventures. The subsections compare the findings to previous research and outline implications for theory and practice.

7.3.1. Dominant logics determine development patterns

Reviewing model conceptualisation, formalisation, case simulations, and scenario simulations, two different types of performance development patterns can be identified. These reflect the part of managers' and entrepreneurs' dominant logic that captures if a venture is willing to hire more employees or is operating at its cap on employee numbers. These two types correspond to the scaling up and exploiting size growth states in the above framework (Figure 7-1). Model conceptualisation identified these caps on employee numbers as one element of the dominant logic (Subsection 3.3.2). The chapter hypothesised that these might also limit value creation and the share of value captured for companies operating at their cap on employee numbers. However, the chapter could not predict the development of value capture of companies without a cap on employee numbers (Subsection 3.4.3). Therefore, the formal model, which allows simulations and the observation of performance development, gives consideration to the dominant logic. It influences hiring and fundraising decisions in the firm managing subsystem (Section 4.5). Scenario simulations of the formal model show that companies operating at their cap on employee numbers can grow their value creation and improve their share of value captured up to a maximum in a goal-seeking manner (Section 6.1). Companies below or without a cap on employee numbers can grow value creation exponentially. They still develop towards a share of value captured in a goal-seeking manner (Section 6.2). Simulations reveal these two types of behaviour across different contexts such as business model designs and environments (Section 6.4). Thus, a venture's type of dominant logic determines its development pattern. This development is also observable for case companies. A prime example is Alpha, which share of value captured develops in a goal-seeking manner over the observation period (Subsection 5.5.1).

These findings align with previous research on the importance of management's growth intentions and growth paths theory. Research on management's growth intentions and outcomes has previously argued that "if an entrepreneur chooses to grow his or her business it is likely that growth will actually occur" (Davidsson, 1991; Delmar and Wiklund, 2008; Davidsson, Steffens and Fitzsimmons, 2009; Kirkwood, 2009, p. 485; Cassia and Minola, 2012; Hesse and Sternberg, 2017). This thesis aligns with this view as a manager's type of dominant logic reflects a willingness to increase the scale of operations needed to support growth in value creation. It adds that companies may grow, although at decreasing rates towards their natural performance levels, even when they do not strive to grow their rate of value creation. Thereby, this thesis replicates and explains two patterns observed in growth paths theory which has identified a range of growth paths. The growth of value creation in the framework's two growth states reflect growth paths theory's continuous and plateaued growth (Garnsey and Heffernan, 2005; Garnsey, Stam and Heffernan, 2006). Growth paths theory's other patterns can be reduced to these two patterns. For example, growth setbacks could be observed in worsening environments but have been explained by development towards ever-decreasing performance levels (see Subsubsection 6.4.1.1). Similarly, validating and simulating for other types of companies may show delayed growth, which is particularly common, for example, among biotechnology companies with long development cycles (Garnsey, 1998). Samples of digital ventures before their market launch in the ideation stage may also show such behaviour. In addition to the development of value creation, this thesis has also revealed the goal-seeking development pattern of the share of value captured within the framework's two growth states.

These insights have implications for theory and practice. Firstly, theory needs to consider the dominant logic as the primary driver of company growth. Without the knowledge of an entrepreneur's growth ambitions, a theory cannot determine if growth was unfeasible or not desired. Secondly, researchers need to determine where on its development path a venture is to understand if performance changes are driven by to goal-seeking mechanisms or managerial decisions. Lastly, entrepreneurship theory, which considers growth the primary outcome of companies, should also consider value capture. As this thesis illustrates, growth is driven primarily by intentions (if capital is available to sustain the firm). Thus, the share of value captured can indicate if such growth is attractive for a venture.

This is also applicable to managers and entrepreneurs of digital ventures. The two growth states in the above framework that depend on their dominant logic (Figure 7-1) provide clear expectations of their performance development. Like researchers, they should not consider growth as the sole outcome of their venture. It is a managerial choice. Rather, they should also consider their venture's ability to capture value and expect it to develop in a goal-seeking manner regardless of the growth state. Therefore, they must ensure that the share of value capture towards which they develop is positive, i.e. create the requirements allowing the development of an ability to capture value This requires looking at the different trajectories within the two growth states (Subsection 7.3.2) and the penalty incurred for growth on value capture (Subsection 7.4.1).

7.3.2. Contextual factors determine trajectories and levels within patterns

While a company's dominant logics determines its performance development pattern, this thesis has illustrated the diversity of performance outcomes within the framework's two growth states (Chapter 6). These differences depend on the model's exogenous, contextual factors. Model conceptualisation (Section 3.3) and formalisation (Chapter 4) grouped these variables. They regarding the environment, business model design, capability development, and specific targets of the dominant logic. Simulations of case companies have shown that companies differ diversely regarding these elements and change contextual variables during state transitions (Chapter 5). Scenario simulations illustrate the influence of the dominant logics' targets and capability development, which the management can influence during the growth process (e.g. Subsections 6.1.2, 6.1.2). They also illustrate the impact of environmental factors and business model designs, which are hard to reverse once selected (Section 6.4). The simulations have shown that these contextual variables have different effects depending on the growth states of the framework. They affect both natural performance levels towards which companies develop when operating at their cap on employee numbers in the exploiting size state (Section 6.1). Thus, companies are required to create the conditions for ultimately superior value creation and capture through the contextual factors. For companies operating below or without employee caps in the scaling up state, they determine the value creation growth rate and the level towards which the share of value captured develops (Section 6.2). Thereby, ventures can use the contextual factors to balance the two performance outcomes and create the requirements to grow at higher rates while maintaining an ability to capture value.

These contextual factors can account for the diversity in performance outcomes observed in empirical studies. The factors that determine these levels are in line with previous findings on company performance about the importance of the external environment (Porter, 1985, 2008; Romanelli, 1989; Zhang, Lichtenstein and Gander, 2015), business model designs (Amit and Zott, 2001; Zott and Amit, 2007, 2010; Teece and Linden, 2017; Täuscher and Abdelkafi, 2018), human resource management and capabilities (Nelson and Winter, 1982; Porter, 1996; Baron and Hannan, 2002), and the impact on managerial targets (Davidsson, 1991; Delmar and Wiklund, 2008; Kirkwood, 2009; Cassia and Minola, 2012; Hesse and Sternberg, 2017). This thesis was able to combine these separate streams of research into one model. Thus, it provides a holistic and systemic account of performance development consistent with previous research. The influence of these factors on performance levels implies that theory needs to consider all of them systematically too. Without considering all factors, firm development may not be fully accounted for. Managers must select and improve the contextual factors to create the requirements and conditions allowing their ventures to develop an ability to capture value while growing value creation. They do so when establishing their ventures and through continuous improvements, reflecting the two additional elements in the above framework.

When establishing their companies, managers and entrepreneurs must select appropriate environments and design effective business models. Due to their difficulty in reversing these factors, managers should select their environment, design their business model, and validate their selection before scaling up (Marmer *et al.*, 2011; Marion *et al.*, 2015; Ramadan *et al.*, 2016; Quinones, 2017; Zaheer *et al.*, 2019; Zaheer, Breyer and Dumay, 2019). Thus, the framework considers these factors in its establishment state before transitioning to scaling up or exploiting its size (Figure 7-1). Simulating the model has shown that customers using the product intensively, developing higher switching costs, and recommending the product led to superior performance outcomes. Moreover, digital ventures should strive to link their technology to complementary products. With its target customer segments, a venture also selects the competition for these customers, which it should strive to minimise. Common tools from strategic management may help entrepreneurs to do so, including, but not limited to, Porter's Five Forces, strategic group analyses, or industry life-cycles (Porter, 1985, 2008; Johnson, Scholes and Whittington, 2008; Grant, 2016; Aaker and McLoughlin, 2017). Selecting an environment, they should strive to identify blue oceans, i.e. uncontested market spaces with unmet customer needs (Kim and Mauborgne, 2005, 2017). Moreover, the venture should strive to design business models with low input costs and efficient activity systems. Digital entrepreneurs should validate their selection and design before transitioning to one of the other two growth states of the framework. They should explicate their assumptions and simulate their venture's development using the model developed in this thesis.

Digital ventures also need to pursue continuous improvements and alter their performance development through the magnitude of their targets while operating their business. Improving internal operations to accelerate capability development (e.g. improving employee training and turnover), external improvements (e.g. linking to complementary producers or incentivising customers to recommend the product), and technology development all positively affect the ability to capture value. For scaling up ventures, they soften the adverse effect of growth on value capture. For ventures exploiting their current size, they increase the levels of value creation and capture towards which the venture develops. Thus, such continuous improvements should be pursued in both of the framework's two growth states (Figure 7-1).

7.4. What relationship(s) exist(s) between value creation and capture?

This thesis has also modelled the complex relationships driving value creation and capture, and their connecting feedback mechanisms. The simulations in this thesis show that the impact of growth in value creation on the share of value captured changes over time. They show that growth in value creation adversely affects value capture during periods of growth but has minor positive effects after periods of growth. The two subsections below review the evidence of this thesis for these insights, compare them to previous literature, outline their implications for the theory and practice, and link them to the above framework.

7.4.1. Growth in value creation adversely affects the share of value captured during periods of growth

The simulations of the model developed in this thesis have revealed two trade-offs between growth in value creation and the share of value captured during the framework's scaling up growth state. Firstly, ventures growing without or below their cap on employee numbers develop towards lower levels of value captured (Subsection 6.2.1). The higher the growth in value creation, the lower the share of value captured towards which the venture develops (Subsection 6.2.2). These lower levels have been explained by continuously mobilising resources from the external environment. These include, for example, new employees that lack firm-specific knowledge or new customers that are yet to develop switching costs. These influences are visible during model conceptualisation (Subsection 3.2.3) and each subsystem (e.g. Subsection 4.3.3), in which new hiring to reach goals reduces capabilities. Secondly, the increase in growth targets causes a temporary fall in the share of value captured (Subsection 6.2.2). This temporary fall can be explained by differences between inputs to the growth process and its outcomes. The venture requires more employees to achieve its more ambitious targets. As soon as it employs these, it incurs their associated cost, as conceptualised (Subsection 3.1.2) and formalised in the value capture subsystem (Section 4.2). However, it takes time until these new employees mobilise and establish the resources that create value.

These findings confirm some of the previous research on performance outcomes (e.g. Hambrick and Crozier, 1985; Nicholls-Nixon, 2005; Stam and Garnsey, 2006). The introduction has outlined literature finding positive, negative, and no impact of growth on profitability. During periods of growth, this thesis is thus aligned with the literature finding negative effects of growth. It has incorporated the negative impact of growth on capabilities highlighted in growth paths theory into the model developed in this thesis. In addition, the model was able to show the impact of these lower capability levels on the share of value capture. It has also found similar mechanisms lowering customers' average usage intensity and switching costs. Superficially, these results conflict with the literature highlighting the benefit of growth, including economies of scale, network effects, and learning effects (Katz and Shapiro, 1985; Chandler and Jansen, 1992; Davidsson, Steffens and Fitzsimmons, 2009). As the next subsection illustrates, some of these benefits exist. However, they are outweighed by the negative effects that counteract them during the scaling up growth states. Moreover, not all benefits of growth outlined in the literature have been found. For example, learning effects could not be identified as an outcome of growth as new employees need to internalise this knowledge before becoming productive (Section 3.2.3). For theory, this implies that learning should be considered on an individual level rather than on an organisational level (Garnsey, 1998; Penrose, 2009).

The adverse effects of growth in value creation have implications for managers striving to grow their value creation and develop an ability to capture value. Firstly, they should strive to minimise the negative impact of growth when establishing their venture and through the continuous improvements in the framework (Figure 7-1). Thereby, they create the requirements to capture value while increasing their growth in value creation. Secondly, managers must carefully prioritise growth rates and the share of value captured. The higher the growth rates, the higher the temporary fall in value creation and the higher the funding required to sustain the venture. Entrepreneurs may thus need to raise sufficient capital to sustain periods of growth or reduce their target growth rates to sustainable levels, reflecting the venture capital-funded and bootstrapped companies in the scaling up state of the framework.

7.4.2. Growth in value creation has minor positive effects on the share of value captured after periods of growth

Rather than having a positive impact during the period of growth, growth seems to pay off after periods of growth. Simulations show this by exploring transitions between growth states with a dominant logic without caps on employee numbers to a dominant logic with a cap on employee numbers (Subsection 6.3.1). Thus, these companies are transitioning from scaling up to exploiting size states of the above framework (Figure 7-1). These simulations also show that the higher the growth targets during the growth period, the larger the benefit after growth (Subsection 6.3.2). These benefits take two forms. Firstly, growth scales up the venture and enables it to develop towards a higher natural rate of value creation when employees are maintained (Subsection 6.3.3). Secondly, growth creates economies of scale that slightly increase the share of value captured. Model conceptualisation shows that not all costs develop with the venture's user and customer base and the venture can spread, for example, development costs and amortisation over more customers (Subsection 3.2.2). Together these two mechanisms accelerate the accumulation of financial resources. Due to economies of scale, scaling up value creation through the customer and user base positively affects a venture's ability to capture value. However, these effects are minor compared to the overall development of the share of value captured in simulations, which companies achieve through, for example, technology development and improving usage intensities.

Researchers were right to propose that growth has a positive effect (e.g. Katz and Shapiro, 1985; Chandler and Jansen, 1992; Davidsson, Steffens and Fitzsimmons, 2009). The more nuanced approach of this thesis that acknowledges temporality and resource stock accumulation was required to understand when and how these positive effects occur. Once the managerial challenges of scaling up are no longer an issue, companies can reap its benefit through economies of scale. However, while this thesis could identify economies of scale, they only had small effects. This might be a special characteristic of the digital context. Firstly, the asset lightness of digital ventures and the ease of establishing them may explain the difference which was hardly significant. Because digital ventures do not hold many depreciating assets and technology can be created easily (Kraus *et al.*, 2018), there are few fixed costs to spread over more customers. Secondly, variable costs may be higher than practitioners expect. Digital entrepreneurs may claim that their products can be distributed at zero marginal costs, thus growing themselves profitable (Staykova and Damsgaard, 2015; Teece and Linden, 2017). However, digital ventures still require significant marketing, servicing, and managerial staff that are driven by the number of customers and users. During model validation (Chapter 5), the case companies show that digital ventures incur significant costs to acquire customers, service them, and manage these marketing and servicing employees. Such employee requirements have already been identified for e-commerce companies pursuing high growth strategies (Oliva, Sterman and Giese, 2003; Sterman *et al.*, 2007).

Together, the adverse effects of growth on the ability to capture value during growth periods and the positive effects after growth periods have implications for theory. Theory needs to consider size and growth conceptually different and acknowledge their temporal relationship. While size accumulates over time and positively affects the ability to capture value, growth as the change in size over a period has a negative impact. The minor positive impact of size implies that researchers need to determine not just if a statistically significant relationship exists but also the size of its effect. A positive relationship due to prior growth should be expected. However, other variables should be altered to develop an ability to capture value. The benefit of growth through a larger size with only minor improvements in the share of value captured has implications for managers striving to develop an ability to capture value. Contradicting the general views of practitioners that one can grow a digital venture into profitability, managers should scale up to exploit an already working business concept rather than make a business concept work through scaling up. After growth, they can reap its benefits by transitioning to the framework's exploiting size state.

Chapter 8: Conclusion

This thesis has investigated two research questions to understand the requirements and priorities allowing digital ventures to develop an ability to capture value while growing their value creation. This conclusion reviews if the methodology has achieved the overall aim, outlines the contributions of this thesis to theory and practice, and proposes areas for future research.

8.1. Review of the research process

This thesis has integrated growth paths theory (Garnsey, 1998) and dynamics states theory (Levie and Lichtenstein, 2010) and adapted the theories for digital ventures using System Dynamics modelling. The use of System Dynamics has allowed the tracing back of the influences on value creation and capture. Unlike traditional quantitative methods that only consider a few elements, the model developed in this way can provide researchers and practitioners with an overview of the complex system and processes driving performance development (Sterman, 2000; Winch and Arthur, 2002). It highlights the critical feedback loops that may improve or deteriorate the ability to create and capture value. It also highlights the contextual influences on the feedback loops and performance outcomes in the environment, business model design, capability development, and regarding the dominant logic. Managers can improve a venture's performance development and develop an ability to capture value while growing value creation by altering these variables. The established, rigorous processes of System Dynamics applied in this thesis allow a high degree of confidence in the model and its findings (Barlas, 1996). The theory-driven development based on growth paths theory, dynamic states theory, and their background literature ensures that relationships in the model are evidence-based and theoretically verified (Tranfield, Denyer and Smart, 2003). By employing a formal modelling methodology, the model also overcomes the limitations of empirical measures for value creation and capture (Langley, 1999; Harrison *et al.*, 2007). It showed how the theoretical conceptualisation of value creation and capture differ from proxies used in empirical studies. Moreover, the model could account for hard/quantitative and soft/qualitative variables simultaneously. The model thus investigates growth and company performance holistically. The developed model has then been validated by comparing its approximation to the historical data of four case companies. Utilising case companies has allowed this thesis to compare the model's approximation against detailed, longitudinal qualitative and quantitative company data.

By simulating hypothetical scenarios, this thesis has identified performance development patterns, relationships of performance outcomes, the dominant feedback loops that cause them, and the variables shifting loop dominance. Simulations have allowed investigating the leverage points that cause different performance development patterns and the trajectories within these patterns. They show that entrepreneurs must select contextual factors carefully and improve them to create the requirements in which their venture can develop an ability to capture value while growing value creation. They also need to be aware that growth reduces their ventures' ability to capture value temporarily. Thereby, the thesis could utilise the strength of computer simulations in which the modeller can investigate the impact of changes in selected variables while creating otherwise identical scenario conditions. This approach significantly contributed to the theoretical insights obtained in this thesis by eliminating confounding factors that other methodologies, such as case studies, need to consider (Coyle, 2000; Sterman, 2000; Warren, 2002; Davis, Eisenhardt and Bingham, 2007; Harrison *et al.*, 2007). In practice, companies are likely to face situations that the model represents through multiple variables. In such cases, the impact on company performance depends on the balance of variable changes, which managers and entrepreneurs can approximate by simulating the model for their ventures.

Comparing ventures' performance development patterns, the structures causing patterns, and identifying the exogenous variables affecting structures has allowed this thesis to illustrate the importance of the management's dominant logic on performance development patterns. Moreover, using the above strength of simulations, this thesis could reveal the causes of diversity in performance development patterns and the impact of growth on the ability to capture value. These findings align and add to the literature discussed in the previous chapter.

They could also be utilised to develop a framework supporting digital ventures to develop an ability to capture value while growing value creation.

8.2. Contribution to theory and practice

This thesis has utilised growth process theories to investigate the performance development and relationships for digital ventures. Below, the contributions to growth process theories, the performance management literature, and the literature on digital ventures are outlined. Contributions to practice are outlined with these theoretical contributions.

8.2.1. Contribution to growth process theories and management

This thesis contributes to growth process theories by combining value creation and capture in one growth process theory, integrating two contemporary growth process theories to overcome the limitations of OLC theory, and by developing a complex, formal theory of the growth process.

Firstly, this thesis has focussed growth process theories on two performance outcomes: growth in value creation and the venture's ability to capture value. Growth process theories commonly focus merely on size changes as their focal performance outcome (Penrose, 2009; Davidsson, Achtenhagen and Naldi, 2010). However, growth and size alone are insufficient to sustain a company and growth may even reduce a company's ability to survive (Hirakubo and Friedman, 2008; Thiel and Masters, 2014). Therefore, this thesis has also considered a venture's ability to capture value, expressing if and what fraction of resources a venture is generating through its operating activities (Brandenburger and Stuart, 1996; Lepak, Smith and Taylor, 2007; Bowman and Ambrosini, 2000; Bowman and Ambrosini, 2010). Thus, unlike previous growth process theories, this thesis is not just measuring growth. It contributes to growth process theories by adding value capture as a second performance metric that determines growth's sustainability to growth process theories. Future researchers and managers/entrepreneurs of digital ventures should consider it an equally important outcome during and of the growth process and not pursue growth at the expense of sustaining their company.

Secondly, this thesis has integrated two contemporary growth process theories to overcome the limitations of OLC stage models. OLC stage models were the dominant growth process theory that linked growth stage characteristics and companies' performance development (Hoy, 2006; Davidsson, Achtenhagen and Naldi, 2010). Because OLC stage models have been empirically challenged, contemporary growth process theories have been proposed. However, these are unable to link stage characteristics to development paths. While growth paths theory describes diverse development paths (Garnsey and Heffernan, 2005; Garnsey, Stam and Heffernan, 2006), dynamic states theory conceptualises growth states (Levie and Lichtenstein, 2010). This thesis specified the variables that define a growth state as dynamic states theory conceptualises them. Unlike dynamic states theory, which provides only an abstract definition of growth states (Davidsson, Achtenhagen and Naldi, 2010), this thesis contributes a set of variables that define and constitute growth states. They relate to the management's dominant logic, environmental factors, capability development, and business model design. These variables are exogenous inputs to the model that remain constant during a growth state. This thesis then conceptualised how these state variables affect the endogenous, continuous change among business model elements and performance outcomes that growth paths theory conceptualises. Thus, this model has contributed not only the underlying mechanisms that affect ventures during the growth process but also how they are affected by the elements that constitute growth states over which the management controls.

Thirdly, this thesis contributes a thoroughly tested System Dynamics model as an output that combines the strengths of quantitative, qualitative, and theoretical work. Similar to quantitative investigations of the growth process (e.g. Hamilton, 2012; Harbermann & Schuilte, 2017), this thesis has provided a clear and tested list of important variables and their relationships. Like qualitative and theoretical research (e.g. Garnsey, 1998; Levie and Lichtenstein, 2010; Hesse Sternberg, 2017), this thesis can account for the complex system that influences the growth process. Future research, discussed below, may simulate and adapt this formal model for different scenarios and contexts as a starting point. Moreover, managers and entrepreneurs may use the model to approximate the development of their ventures, forming a practical contribution of the model developed in this thesis. They may form assumptions about a venture's model inputs and simulate the model to determine the venture's growth in value creation, ability to capture value, the penalty of growth on value capture, and the capital required to sustain growth periods (Vhzquez, Liz and Aracil, 1996; Winch and Arthur, 2002).

8.2.2. Contribution to performance management literature and practice

This thesis also contributes to the performance management literature by identifying two performance development patterns among diverse paths, clarifying the relationship between growth in value creation and the ability to capture value, and contributing to future research methodologically.

Firstly, this thesis identifies two development patterns and contributes to explaining the diverse performance developments of companies. Previous research could not clearly identify the factors that cause companies' diverse performance developments (Davidsson, Steffens and Fitzsimmons, 2009; Brännback *et al.*, 2009; Jang, 2011). This thesis reduces the complexity of performance development paths by identifying and explaining two patterns within those diverse paths. It shows that a management's growth intentions determine the performance development patterns experienced by the company, causing either exponential growth at the expense of value capture or goal-seeking development in both performance outcomes. Contextual factors regarding the environment, business model design, capability development, and dominant logic determine the trajectories within these two patterns. This finding has managerial implications when striving to develop an ability to capture value. Managers need to select attractive environments, develop effective business models, and continuously improve them to ensure their natural performance levels are positive, thus creating the requirements to develop an ability to capture value.

Secondly, the thesis has illustrated the trade-offs and benefits of growth in value creation and the share of value captured, contributing to clarifying the inconclusive results of previous investigations. Previous research on the relationship between growth in value creation and the ability to capture value could not clearly identify if growth has a positive (Katz and Shapiro, 1985; Chandler and Jansen, 1992; Davidsson, Steffens and Fitzsimmons, 2009), negative (Fitzsimmons, Steffens and Douglas, 2005; Brännback *et al.*, 2009; Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009), or no impact (Markman and Gartner, 2002; Bottazzi *et al.*, 2010) on the ability to capture value. Similarly, it could not establish if an ability to capture value has a positive (Fitzsimmons, Steffens and Douglas, 2005; Brännback *et al.*, 2009; Davidsson, Steffens and Fitzsimmons, 2009; Steffens, Davidsson and Fitzsimmons, 2009), negative (Reid, 1995; Lee, 2014, 2018), or no impact on growth (Markman and Gartner, 2002; Coad, 2002). This thesis has identified temporality as a possible explanation for the inconclusive and conflicting results. While growth has a negative impact on the ability to capture value during periods of growth, the increase in size that it causes has a positive impact. If an overall positive or negative effect is observed depends on firm-specific growth rates and delays in the system. This has managerial implications as growth goals are a managerial choice and part of the dominant logic. Therefore, executives can reduce their growth goals to improve the ability to capture value and manage their company's ability to achieve both performance outcomes.

In addition, this thesis also makes methodological contributions to the performance management literature. Firstly, this thesis' systemic investigation has allowed the incorporation of a wide variety of factors affecting value creation and capture into the developed model. These factors have previously been considered in different sets of literature, and the findings of this thesis align with them. This literature regards, for example, the importance of the external environment (Porter, 1985, 2008; Romanelli, 1989; Zhang, Lichtenstein and Gander, 2015), business model designs (Amit and Zott, 2001; Zott and Amit, 2007, 2010; Teece and Linden, 2017; Täuscher and Abdelkafi, 2018), human resource management and capabilities (Nelson and Winter, 1982; Porter, 1996; Baron and Hannan, 2002), and the impact on managerial targets (Davidsson, 1991; Delmar and Wiklund, 2008; Kirkwood, 2009; Cassia and Minola, 2012; Hesse and Sternberg, 2017). The contribution of this thesis is combining them into a single theory and model. Future research should consider all factors that determine performance patterns and trajectories. Secondly, this project has also given attention to the validity of proxies to measure value creation and capture. It has shown that revenue and profit margins are reasonable proxies for digital venture's performance outcomes, while researchers should avoid return on assets as a proxy for a digital venture's share of value captured.

8.2.3. Contribution to digital ventures

This thesis integrated growth process theories for and investigated company performance in the context of digital ventures. Therefore, it also contributes to current knowledge about this specific context and type of company.

The model as an output of this thesis represents a formal theory of growth for digital ventures. This thesis develops a growth process theory specific to digital ventures. Thus, it has fulfilled the call to contextualise general theories for digital ventures and their specific aspects (e.g. Kraus *et al.*, 2018; Nzembayie, Buckley and Cooney, 2019; Zaheer, Breyer and Dumay, 2019). Thus, thesis has, for example, included their asset-lightness, the importance and continuity of product development, and the interactions of different customer groups. While such issues were often mentioned in growth process theories, they were never considered essential parts of those theories. For example, as outlined in the introduction of this thesis, many OLC stage models (e.g. Kazanjian and Drazin, 1990) may consider research and development an initial step before other activities. As this thesis shows, it is a continuous activity increases growth in value creation and the share of value captured simultaneously. Future researchers investigating digital ventures may build on these identified issues and specifications.

Regarding performance outcomes, managers and entrepreneurs are alerted that their shared belief on growing a company into profitability is flawed. Instead, highlight is given to the importance of appropriate contextual factors to create the requirements to develop an ability to capture value. Moreover, digital entrepreneurs must be aware that their high growth intentions negatively affect their share of value captured and may increase capital requirements.

8.3. Limitations and future research

Future research may have occasion to further test the model developed in this thesis. Here the model has been tested against four companies after an extensive and rigorous identification and vetting process, thereby going beyond the validation executed for many System Dynamics models that are developed and validated for one company (e.g. Coyle and Exelby, 2000; Oliva, Sterman and Giese, 2003). However, in comparison with other quantitative methods, this sample size may be perceived as a limitation. Testing the model with further studies may reveal additional insight and areas for improvement. Researchers might, for example, use companies with alternative development paths or companies that are already profitable. Researchers should also focus on companies employing freemium and content-based business models. Lastly, future research may use primary, longitudinal data and work with companies that are less secretive about their operations. Thereby, the model can be improved based on direct feedback from practitioners (Luna-Reyes and Andersen, 2003). As Sterman (2002, p. 501) argues, "all models are wrong". By means of future research, confidence in the model can be further enhanced.

Future research may also be able to build on the developed model and expand its scope of application to other types of companies. The research here has focussed on companies providing fully digital products and services. Further research could strive to generalise findings of this thesis and evaluate if they apply in other contexts. Four areas seem promising:

- A first area is to broaden the application of the model as regards diversification and acquisition strategies. Future research could consider the relationships between different product lines and the step changes in resources caused by acquiring other companies.
- A second step may be to expand the model to account for e-commerce and other companies combining digital and physical products. This would require, for example, the extension of the model through additional resource stocks

and activities that the digital ventures in this thesis do not require. Examples of such stocks and activities include different types of inventories, manufacturing, and logistics.

- Thirdly, future research could adapt the model for different contexts. Such research may use the development model and methodology to pursue such adaptations. Areas for such research were identified in the methodology section where of this thesis excluded, for example, electronics, natural resources, and biotechnology companies from the sample.
- Lastly, financial service companies are a promising context for future research. As noted in the methodology, growth process theories claim to be concerned with just producing companies and so exclude financial companies from their considerations (Penrose, 2009). The growth of investment companies may thus be unchartered territory and can therefore provide the opportunity to test existing growth process theories on firms which are usually excluded. The methodology and model proposed in this thesis may guide future researchers in doing so.

Rather than adding and adapting the model, future research would also be able to build on the findings of this research. This concerns improving the generality of the results of the findings and focussing on best practices to alter performance:

- A step for future research may confirm the findings of this thesis through alternative methods. Different research methods have different advantages and disadvantages. The strengths of the simulation methodology utilised here include, for example, the measurement of theoretical measures, accounting for hard and soft factors, and creating hypothetical scenarios. However, due to its complexity, it has been limited to small sample sizes. Additional research may further generalise and test the findings of this project, for example, through large datasets of companies.
- Future research may also focus on the methods that best improve company performance. The researcher here has attempted to outline what variables matter and what impact they have on performance developments and relationships. In the discussion, some guidelines have been provided to alter these variables. Future research could systematically evaluate published literature (Tranfield, Denyer and Smart, 2003) or identify best-practice

through qualitative and quantitative studies to identify how these variables could be altered by managers and entrepreneurs. Thereby, future research could develop a "playbook" that builds on the framework developed in the discussion chapter of this thesis.

When pursuing such lines of inquiry, it is recommended that future researchers adhere to the principles outlined in this thesis. They should evaluate the management's dominant logic as it is the primary driver of performance development patterns. Moreover, future researchers should control for all contextual factors outlined in this thesis. Researchers should also use revenue growth and profit margins as proxies of more theoretical performance measures.

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The development paths and relationships of value creation and capture: an investigation of digital ventures using System Dynamics

Appendices

Martin Alexander Lycko

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Appendix A: Additional model details

This appendix outlines additional details of the formal model. The additional details described in this appendix reproduce different structures already explained in depth in Chapter 4 of this thesis. For example, the main body of the thesis described technology developing capabilities. This appendix uses the described structure and equations to formalise capabilities related to other activities. Together, the details in this appendix and Chapter 4 of the thesis illustrate all structures and equations required to reproduce the formal model. The appendix follows the same structure of subsystems utilised in Chapter 4. It first outlines additional model elements for the value creation and value capture subsystems. This appendix then presents additional details for the user and customer, firm managing, and content creation subsystems[29].

A.1. Value creation subsystem

The main body of the thesis has split digital ventures' value creation into the value created for customers and the value created for users. It has then further modelled the value created for customers. It depends on the customer base, product strength for customers, and customer usage intensity. The section noted that the mechanisms to create value for users and premium users follow the same structures. This section adapts and describes these structures and equations for users and premium users.

A.1.1. Value creation for users and customers

The main body of the thesis modelled the rate of value creation for customers (Subsection 4.1.2). However, digital ventures may distinguish between customers, users, and premium users (Afuah and Tucci, 2000; Kollmann, 2006; Teece, 2010; Zott, Amit and Massa, 2011; Roma and Dominici, 2016; Voigt and Hinz, 2016; Möller *et al.*, 2020). Thus, this subsection adapts the main body's structure to

[29] Chapter 4 of the thesis described the complete technology development subsystem.

model the rate at which digital ventures create value for users and premium users (Figure A-1). The value created for customers depends on the customer base and the rate of use value creation for customers. Therefore, the rates of value creation for users and premium users depend on their respective stocks and rates of use value creation. The use value depends on the product strength, the usage intensity, and the advantage of the premium product for its users.

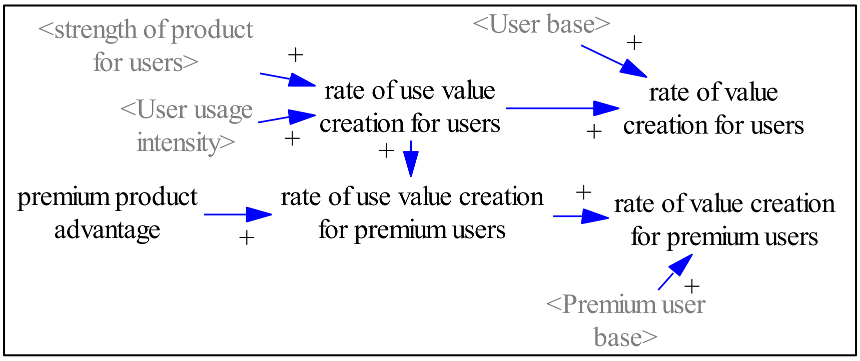


Figure A-1: Rates of value creation for users and premium users

The model adapts the equations for customers in the main body. Thus, it calculates the *rate of value creation for users* and the *rate of value creation for premium users* by multiplying together the respective rates of use value creation and user bases (Equation A-1, A-2).

$$\text{rate of value creation for users} = \text{User base} * \text{rate of use value creation for users} \qquad \text{Eq A-1}$$

$$\text{rate of value creation for premium users} = \text{Premium user base} * \text{rate of use value creation for premium users} \qquad \text{Eq A-2}$$

The customer and user subsystem in the main body has already modelled the user bases. The model calculates the *rate of use value creation for users* in the same manner as the use value for customers. The model thus derives it by multiplying together the *user usage intensity* and the *strength of product for users* (Equation A-3). In exchange for paying for the product, premium users get access to additional or improved features. Therefore, they generate value from a product at a higher rate (Teece, 2010; Roma and Dominici, 2016; Voigt and Hinz, 2016; Möller *et al.*, 2020). This higher rate is reflected in the *premium product* *advantage*. It captures the superiority of the premium product over the base version of the product or service. This advantage is multiplied with the use value for users to derive the *rate of user value creation for premium users* (Equation A-4).

$$\text{rate of use value creation for users} = \text{User usage intensity} * \text{strength of product for users} \quad \text{Eq A-3}$$

$$\text{rate of value creation for premium users} = \text{rate of use value creation for users} * \text{premium product advantage} \quad \text{Eq A-4}$$

The product strength for users and the user usage intensity are further reviewed below.

A.1.2. Value drivers determining the product strength for users

The main body of the thesis has outlined different drivers of value creation in a digital context for customers (Subsection 4.1.3). These are the technological quality, content quality, direct and indirect network effects, and the quality of complementary products. These value drivers also apply to users and determine the product's strength for them (Figure A-2).

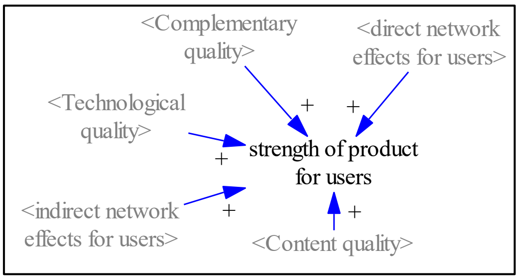


Figure A-2: Strength of product for users

Adapting the equation used to calculate the product strength for customers, the *product strength for users* depends on these value drivers. Each value driver has a value of one if the venture uses it and zero if the venture does not employ it. The model multiplies together these value drivers after confirming their value with the custom HasValue function (Equation A-5). The custom macro returns one if a value driver is not utilised to ensure that the unemployed drivers do not affect the multiplication.

$$\begin{aligned}\text{strength of product or service for customers} \\ &= \text{HasValue(Technological quality, 1)} \\ &* \text{HasValue(Content quality, 1)} \\ &* \text{HasValue(direct network effects for users, 1)} \\ &* \text{HasValue(indirect network effects for users, 1)} \\ &* \text{HasValue(Complementary quality, 1)}\end{aligned} \qquad \text{Eq A-5}$$

The main body of the thesis has modelled the technological quality (Subsubsection 4.1.3.1). The complementary quality is an exogenous input. The network effects for users and the content quality are modelled below. The model indexes these value drivers and thus the product strength for users in the same manner as the product strength for customers. All employed value drivers and product strengths have an initial value of one. This indexes the initial rate of value creation at one too.

A.1.2.1. Network effects for users

Users may be affected by positive and negative as well as direct and indirect network effects (Stampfl, Prügl and Osterloh, 2013; Staykova and Damsgaard, 2015; Gandia and Parmentier, 2017; Täuscher and Abdelkafi, 2018; Zhu and Bao, 2018). While direct network effects depend on the venture's user base, indirect network effects depend on its customer base. The initial bases normalise the network effects. It indexes them at an initial value of one. Moreover, the model uses policy switches to deactivate and activate positive and negative network effects (Figure A-3). Thus, the model uses the same structure and equations introduced in the main body of the thesis for customers (Subsubsection 4.1.3.2),

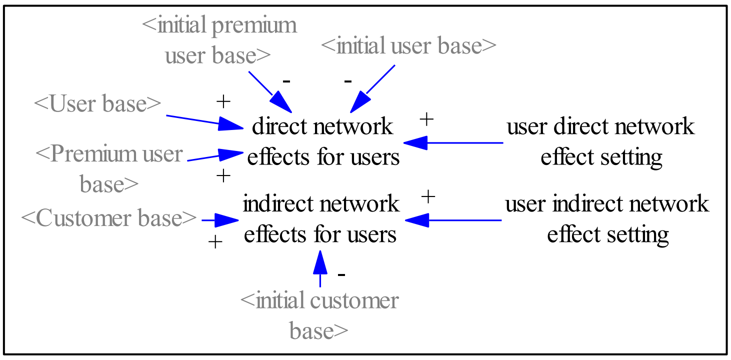


Figure A-3: Network effects for users

The model adapts the equations for customer network effects. It thus calculates the user network effects using an if-clause to check if a network effect is present. These are expressed in the respective *network effect settings*. If the respective setting is zero, there are no network effects, and they are thus zero. If network effect settings are positive (1), the functions increase network effects proportional to the increase in the user or customer bases. If network effect settings are negative (-1), the functions create a decline in network effects proportional to increases in the user or customer bases (Equation A-6, A-7).

$$\begin{aligned}&\text{direct network effects for users}\\&= \text{IF THEN ELSE(user direct network effect setting}\\&= 0, 0, ((\text{Premium user base} + \text{User base})/(\text{initial user base}\\&+ \text{initial premium user base}))\text{\^{}user direct network effect setting)}\end{aligned} \qquad \text{Eq A-6}$$

$$\begin{aligned}&\text{indirect network effects for users}\\&= \text{IF THEN ELSE(user indirect network effect setting}\\&= 0, 0, (\text{Customer base}\\&/\text{initial customer base})\text{\^{}user indirect network effect setting)}\end{aligned} \qquad \text{Eq A-7}$$

The customer and user subsystem in Chapter 4 of this thesis has modelled the user and customer bases. The analyst sets the network effect settings as exogenous policy switches (Coyle, 1996).

A.1.2.2. Content quality

The content quality is a value driver for digital ventures that offer content-based products or services (Saaksjarvi and Lassila, 2005; Kim, Oh and Shin, 2010; Bradley *et al.*, 2012; Ojala, 2016; Kim and Kim, 2017; Cristofaro, 2020).

Examples of such business models are online newspapers and streaming services (Afuah and Tucci, 2000; Asvanund *et al.*, 2004; Saaksjarvi and Lassila, 2005; Mikalef, Giannakos and Pateli, 2013; Koch and Windsperger, 2017; von Briel, Recker and Davidsson, 2018). This value driver was included in the model because it has been identified in the literature on digital ventures (see Subsection 4.1.3). It is presented in this appendix because it is not employed by any of the case companies identified through the extensive and rigorous sampling process. Moreover, its structure is similar to the technological quality. The model uses the *content quality* to reflect the quality of the average content item offered by the venture. As all employed value drivers, the initial content quality has a value of one to index the rate of value creation. Like the technological quality, the content quality improves over time. While the technological quality improves along the technology s-curve towards its maximum, the content quality improves towards the *quality of new content items* depending on the *fraction of new content items* (Figure A-4).

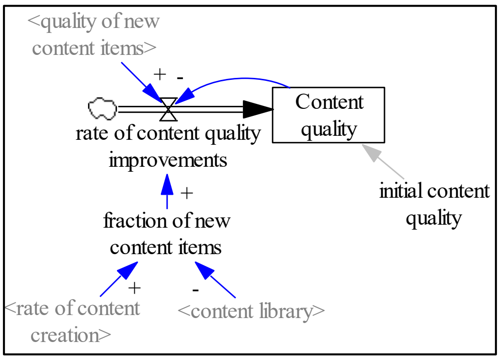


Figure A-4: Content quality

The model uses the same structure employed repeatably in this thesis to update averages like the usage intensities or capabilities. The model thus relies on verified and validated structured and equations. It adjusts the *content quality* through the *rate of content quality improvements* (Equation A-8). This variable moves the content quality towards the *quality of new content items* depending on the *fraction of new content items* (Equation A-9, A-10).

$$\text{Content quality} = \text{initial content quality} + \int (\text{rate of content quality improvements}) \qquad \text{Eq A-8}$$

$$\text{rate of content quality improvements} = (\text{quality of new content items} - \text{Content quality}) * \text{fraction of new content items} \tag{Eq A-9}$$

$$\text{fraction of new content items} = \text{XIDZ}(\text{rate of content creation}, \text{Content library}, 1) \tag{Eq A-10}$$

The content creation subsystem in this appendix presents the content library, rate of content creation, and quality of new content items.

A.1.3. User usage intensity

How intensively users make use of a digital product or service affects the value they derive from it. As for customers, this usage intensity changes over time due to learning, personalisation, and feature adoption (Amit and Zott, 2001; Kim, Oh and Shin, 2010; DaSilva *et al.*, 2013; Deng and Wang, 2016; Tucker, 2018). The model uses the customer usage intensity structure (Subsection 4.1.4) to model the user usage intensity. It increases for existing users and falls when new users are acquired (Figure A-5).

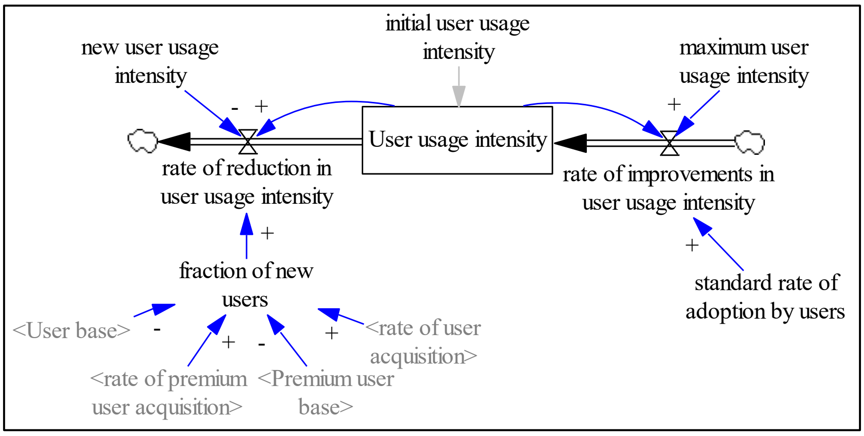


Figure A-5: User usage intensity

The model applies the customer's structure and equations to users. The *user usage intensity* accumulates based on *improvements in usage intensity for existing users* and *reductions in usage intensity* for new users (Equation A-11). The improvements are modelled using Sterman‘s (2000) s-curve that adjusts a standard rate (Equation A-12). The adjustments for new users depend on the *new user usage intensity* and the *fraction of new users* (Equation A-13, A-14).

$$\begin{aligned} &\text{User usage intensity} && \text{Eq A-11} \\ &\quad = \text{initial user usage intensity} \\ &\quad + \int (\text{rate of improvements in user usage intensity} \\ &\quad - \text{rate of reduction in user usage intensity}) \end{aligned}$$

$$\begin{aligned} &\text{rate of improvements in user usage intensity} && \text{Eq A-12} \\ &\quad = \text{standard rate of adoption by users} \\ &\quad * \text{User usage intensity} \\ &\quad * \text{ZIDZ(maximum user usage intensity} \\ &\quad - \text{User usage intensity, maximum user usage intensity)} \end{aligned}$$

$$\begin{aligned} &\text{rate of reduction in user usage intensity} && \text{Eq A-13} \\ &\quad = (\text{User usage intensity} - \text{new user usage intensity}) \\ &\quad * \text{fraction of new users} \end{aligned}$$

$$\begin{aligned} &\text{fraction of new users} && \text{Eq A-14} \\ &\quad = \text{XIDZ(rate of user acquisition} \\ &\quad + \text{rate of premium user acquisition, User base} \\ &\quad + \text{Premium user base, 1)} \end{aligned}$$

The *initial user usage intensity* has a value of one to index value creation. As for the customer usage intensity, analysts may use different data points to approximate the usage intensity. Please refer to customer usage intensity in the main body of the thesis (Subsection 4.1.4) or Appendix C for a list of examples. The analyst then uses these data points to calibrate the maximum usage intensity, new user usage intensity, and speed of adoption. They are constant during a growth state.

A.2. Value capture subsystem

The model conceptualisation in Chapter 3 has split the share of value captured into three fractions: the value captured from customers and users, the value lost to input providers, and the value lost to resource erosion. Chapter 4 has presented how value is captured from customers and lost to input providers and resource erosion on a more detailed level. It has presented all details regarding the shares of value lost. Additional details exist for the share of value captured from premium users. These are outlined below.

A.2.1. Share of value captured from customers

Chapter 4 of this thesis has modelled the share of value captured. It depends on the bargaining power to customers and the bargaining power to premium users. The descriptions in the main body proceeded to illustrate the development of the bargaining power to customers. It depends on the switching costs of customers and influences from other parts of the model. The two subsubsections below adapt the structures and equations for customers to model the development of the bargaining power to premium users and their switching costs.

A.2.1.1. Bargaining power to premium users

The bargaining power to premium users changes like the bargaining power to customers (Subsubsection 4.2.1.1). Over time, existing premium users develop switching costs that increase the venture’s bargaining power. The venture’s contract periods may delay these adjustments. However, the bargaining power is adjusted when new premium users are acquired that have not yet developed switching costs (Figure A-6).

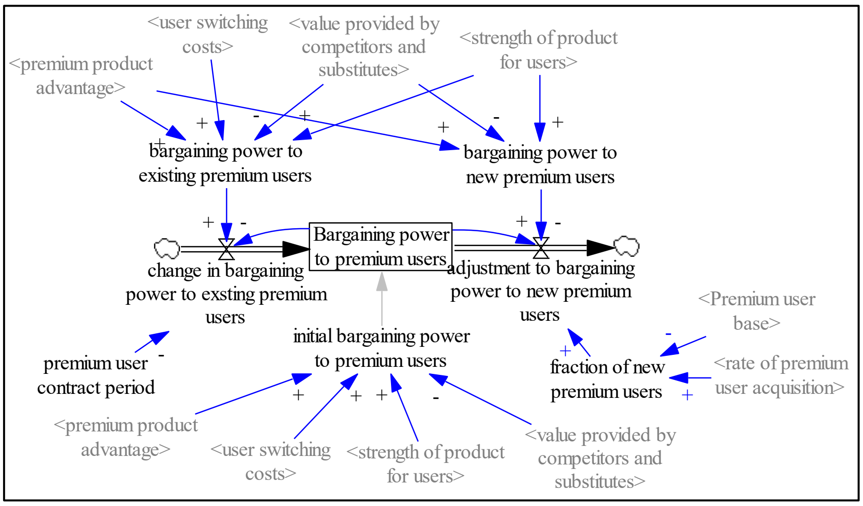


Figure A-6: Bargaining power to premium users

The model reuses the structure and equations developed for customers.

The *bargaining power to premium users* increased through *changes in the bargaining power to existing premium users and* reduces through *adjustments to bargaining power to new premium users* (Equation A-15). This adjustment reduces the bargaining power towards the *bargaining power to new premium users* based on the *fraction of new premium users* (Equation A-16, Equation A-17). The bargaining power to new premium users depends on the *strength of product of users* considering the *premium product advantage* and relative to the *value provided by competitors and substitutes* (Equation A-18). The changes for existing premium users adjust the bargaining power towards the *bargaining power to existing premium users* over the *premium user contract period* (Equation A-19). In addition to the factors for new premium users, the bargaining power to exiting premium users also depends on the *switching costs* (Equation A-20). The model uses the same equation and factors to initialise the bargaining power to premium users (Equation A-21).

$$\begin{aligned}&\text{Bargaining power to premium users} \\ &= \text{initial bargaining power to premium users} \\ &+ \int (\text{change in bargaining power to exsting premium users} \\ &- \text{adjustment of bargaining power to new premium users})\end{aligned} \qquad \text{Eq A-15}$$

$$\begin{aligned}\text{adjustment to bargaining power to new premium users} \\ = (\text{Bargaining power to premium users} \\ - \text{bargaining power to new premium users}) \\ * \text{fraction of new premium users}\end{aligned} \qquad \text{Eq A-16}$$

$$\begin{aligned}&\text{fraction of new premium users} \\ &= \text{XIDZ(rate of premium user acquisition, Premium user base, 1)}\end{aligned} \qquad \text{Eq A-17}$$

$$\begin{aligned}&\text{bargaining power to new premium users} \\ &= \text{ZIDZ(strength of product for users} \\ &* \text{premium product advantage, strength of product for users} \\ &* \text{premium product advantage} \\ &+ \text{value provided by competitors and substitutes)}\end{aligned} \qquad \text{Eq A-18}$$

$$\begin{aligned}&\text{change in bargaining power to exsting premium users}\\&\qquad = \text{ZIDZ}(\text{bargaining power to existing premium users}\\&\qquad - \text{Bargaining power to premium users},\\&\qquad \text{premium user contract period})\end{aligned} \tag{Eq A-19}$$

$$\begin{aligned}&\text{bargaining power to existing premium users}\\&\qquad = \text{ZIDZ}(\text{strength of product for users}\\&\qquad * \text{premium product advantage} * (1\\&\qquad + \text{user switching costs}), \text{strength of product for users}\\&\qquad * \text{premium product advantage} * (1\\&\qquad + \text{user switching costs})\\&\qquad + \text{value provided by competitors and substitutes})\end{aligned} \tag{Eq A-20}$$

$$\begin{aligned}&\text{initial bargaining power to premium users}\\&\qquad = \text{ZIDZ}(\text{strength of product for users}\\&\qquad * \text{premium product advantage} * (1\\&\qquad + \text{user switching costs}), \text{strength of product for users}\\&\qquad * \text{premium product advantage} * (1\\&\qquad + \text{user switching costs})\\&\qquad + \text{value provided by competitors and substitutes})\end{aligned} \tag{Eq A-21}$$

The product strength for users has been reviewed in the value creation subsystem in this appendix. The switching costs for users are described below. The value provided by competitors and substitutes has been modelled in Chapter 4 of this thesis (Subsubsection 4.2.1.3). The contract period is set based on statements made in the company's annual reports and websites.

A.2.1.2. User switching costs

Chapter 4 of this thesis has modelled the development of switching costs for customers (Subsubsection 4.2.1.2). They affect the venture's bargaining power towards them. As shown above, the bargaining power to premium users also depends on their respective switching costs. Therefore, the model applies the structure and equations presented in Chapter 4 to model user switching costs. Thus, switching costs develop as users adopt features, learn how to use them, and customise a product (Amit and Zott, 2001; DaSilva *et al.*, 2013; Tucker, 2018). The model expresses switching costs as the relative increase in usage intensity (Figure A-7).

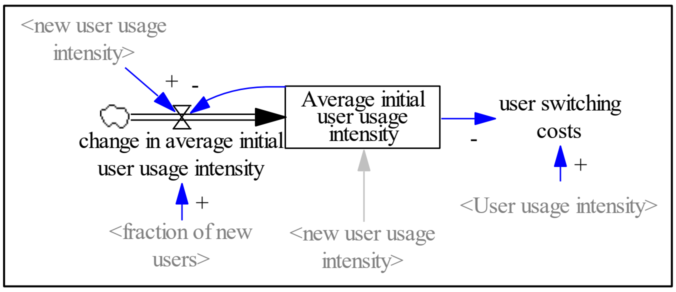


Figure A-7: User switching costs

The model reuses the equations for customer switching costs. It calculates user switching costs by calculating the difference between the current *user usage intensity* and the *average initial user usage intensity*. This difference is then expressed as a fraction of the average initial user usage intensity (Equation A-22). The average rate's initial value is the usage intensity of new users at the beginning of the simulation. It adjusts to reflect changes in the venture's target users (Equation A-23). The *change in average initial user usage intensity* moves the current average towards the *new customer usage intensity* depending on the *fraction of new users* (Equation A-24).

$$\text{user switching costs} = \text{ZIDZ(User usage intensity} - \text{Average initial user usage intensity,} \text{ Average initial user usage intensity)} \qquad \text{Eq A-22}$$

$$\text{Average initial user usage intensity} = \text{new user usage intensity} + \int \text{(change in average initial user usage intensity)} \qquad \text{Eq A-23}$$

$$\text{change in average initial user usage intensity} = \text{(new user usage intensity} - \text{Average initial user usage intensity)} * \text{fraction of new users} \qquad \text{Eq A-24}$$

The inputs to the user switching costs are derived from the customer and user subsystem in Chapter 4 of this thesis and the additional value creation subsystem details in this appendix.

A.3. Customer and user subsystem

The customer and user subsystem presented in Chapter 4 presented the customer base, user base, and premium user base (Section 4.3). The subsystem in the main body shows how the venture acquires new customer and user through marketing activities and word-of-mouth. The venture loses them depending on their lifetime. Chapter 4 presented this churn using the example of customers. The user and premium user lifetimes are formalised below using the same structure and equations. Moreover, ventures' marketing and value delivering activities rely on their respective capabilities. These have not been presented in Chapter 4 because they use the same structure as the venture's technology developing capabilities. They are also illustrated below.

A.3.1. User and premium user lifetime

The user and premium user lifetimes represent how many years the average user or premium user stays with the venture. The model applies the structure developed for customers (Subsection 4.4.4) to model these two lifetimes. It is based on Sterman's (2000) structure for multiplicative effects. It adjusts a standard lifetime for the relative product strength and service capacity adequacy while accounting for the contract terms of premium users (Figure A-8).

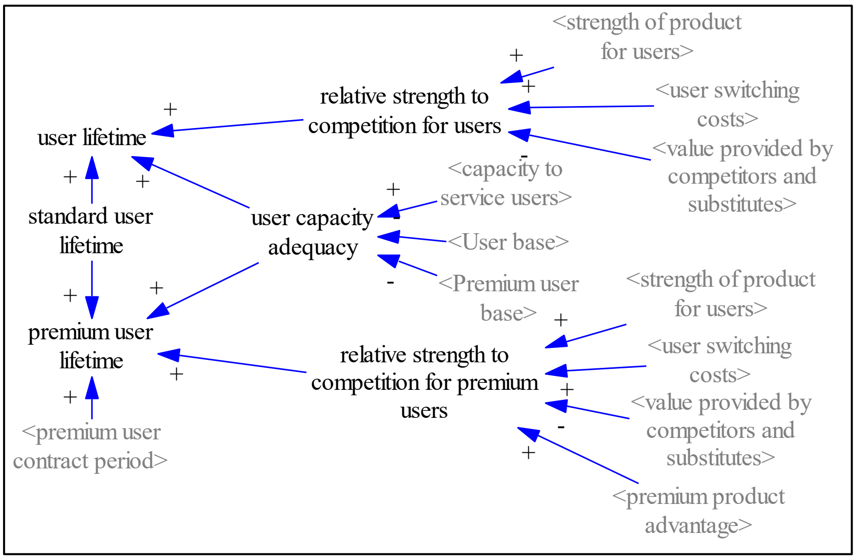


Figure A-8: User and premium user lifetimes

The model calculates the *user lifetime* and *premium user lifetime* by adjusting the *standard user lifetime* by the respective *relative strength to competitors* and the *user capacity adequacy* (Equation A-25). The *premium user contract period* serves as a minimum for the premium user lifetime (Equation A-26).

$$\text{user lifetime} = \text{MAX}(0, \text{standard user lifetime} * \text{user capacity adequacy} \\ * \text{relative strength to competition for users}) \qquad \text{Eq A-25}$$

$$\text{premium user lifetime} \\ = \text{MAX}(\text{premium user contract period}, \text{standard user lifetime} \\ * \text{user capacity adequacy} \\ * \text{relative strength to competition for premium users}) \qquad \text{Eq A-26}$$

The *user capacity adequacy* reflects the fraction of users and premium users that the venture can service adequately. The model calculates it by dividing the *capacity to service users* by the number of indexed users in the *user base* and *premium user base*. The model also caps the adequacy at one when capacity exceeds requirements (Equation A-27). The *relative strength to competition for users* expresses the *strength of product for users* considering *user switching costs* relative to the *value provided by competitors and substitutes* (Equation A-28). The *relative strength to competition for premium users* also considers the *premium product advantage* (Equation A-29).

$$\text{user capacity adequacy} \\ = \text{MIN}\,(1, \text{ZIDZ}(\text{capacity to service users}, (\text{User base} \\ + \text{Premium user base}))) \qquad \text{Eq A-27}$$

$$\text{relative strength to competition for users} \\ = \text{ZIDZ}(\text{ strength of product for users} * (1 \\ + \text{user switching costs}), \text{strength of product for users} \\ * (1 + \text{user switching costs}) \\ + \text{value provided by competitors and substitutes}) \qquad \text{Eq A-28}$$

$$\text{relative strength to competition for premium users} = ZIDZ(\text{strength of product for users} * \text{premium product advantage} * (1 + \text{user switching costs}), \text{strength of product for users} * \text{premium product advantage} * (1 + \text{user switching costs}) + \text{value provided by competitors and substitutes}) \quad \text{Eq A-29}$$

The value creation and capture subsystems in this appendix have modelled the product strength for users, user switching costs, the premium user contract period, and premium product advantage. The user base and premium user base, the value provided by competitors and substitutes, and the capacity to service users have been modelled in Chapter 4 of this thesis.

A.3.2. Capability development

The rates at which the venture's employees can acquire new users and customers and their capacities to service them depend on their capabilities. All capabilities in the model use the same structure as the technology developing capabilities presented in Chapter 4 of the thesis (Subsection 4.3.3). Below, this structure is adapted to model the capabilities of marketing and selling employees and value delivering employees.

A.3.2.1. Marketing and selling capabilities

Marketing and selling employees may acquire the three different types of users and customers distinguished in this thesis. Therefore, their productivity levels are represented by three variables: the ability to acquire customers, acquire users, and acquire premium users. These abilities reflect the indexed number of respective customers each indexed employee acquires per period (Subsection 4.4.2). As with all other capabilities, these productivity levels depend on employee competence, the effect sizes that transform the competence levels to hard impacts, and the adequacy of complementary assets. The model also considers the product's strength relative to competitors for marketing capabilities (Figure A-9).

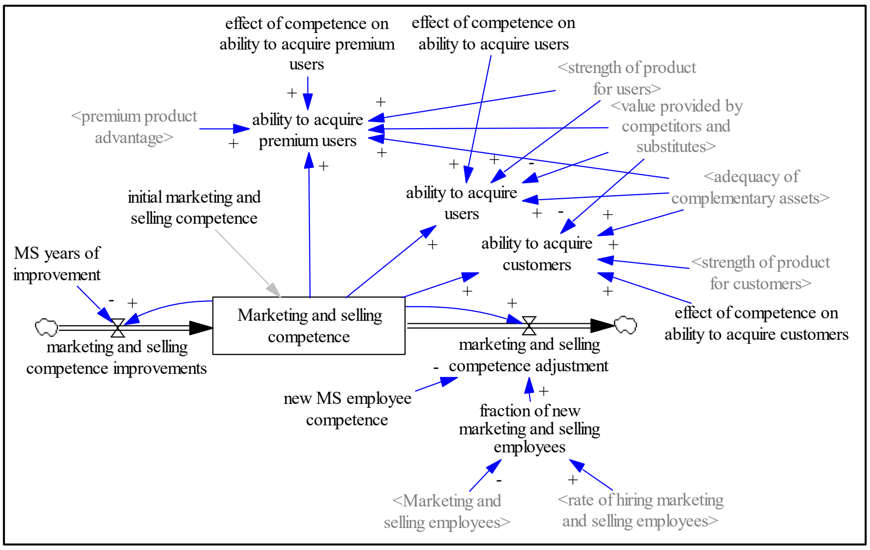


Figure A-9: Marketing and selling capabilities

Employee abilities depend on their *marketing and selling competence*, the respective *effect of that competence* on an ability, and the *adequacy of complementary assets*. The effect sizes transform competence from a soft to hard scale. In addition, marketing and selling employee productivity may be affected by the product's strength (Garnsey, 1998; Bhide, 2000; Garnsey, Lubik and Heffernan, 2015; Hesse and Sternberg, 2017). Therefore, the model adjusts abilities for the respective *strength of the product* relative to the *value provided by competitors and substitutes* (Equation A-30, Equation A-31, Equation A-32).

$$\begin{aligned}&\text{ability to acquire customers} \qquad\qquad \text{Eq A-30}\\&= \text{Marketing and selling competence}\\&* \text{effect of competence on ability to acquire customers}\\&* \text{adequacy of complementary assets}\\&* \text{ZIDZ(strength of product for customers, strength of product for customers}\\&+ \text{value provided by competitors and substitutes)}\end{aligned}$$

$$\begin{aligned}&\text{ability to acquire users} \qquad\qquad \text{Eq A-31}\\&= \text{Marketing and selling competence}\\&* \text{effect of competence on ability to acquire users}\\&* \text{adequacy of complementary assets}\\&* \text{ZIDZ(strength of product for users, strength of product for users}\\&+ \text{value provided by competitors and substitutes)}\end{aligned}$$

$$\text{ability to acquire premium users} \qquad \text{Eq A-32}$$
$$= \text{Marketing and selling competence}$$
$$* \text{ effect of competence on ability to acquire premium users}$$
$$* \text{ adequacy of complementary assets} * \text{ZIDZ(strength of product for users}$$
$$* \text{ premium product advantage, strength of product for users}$$
$$* \text{ premium product advantage}$$
$$+ \text{ value provided by competitors and substitutes)}$$

Like the technology developing competence, the *marketing and selling competence* is scaled between zero and one. It accumulates from the *initial marketing and selling competence* based on competence improvements and competence adjustments (Equation A-33). *Marketing and selling competence improvements* reflect capability improvements through learning and routinisation along Sterman's (2000) s-curve. The speed along the curve depends on the inverse of the *MS years of improvement* as the standard rate (Equation A-34). The *marketing and selling competence adjustment* reduced the competence level towards the *new MS employee competence*. The adjustment's magnitude depends on the *fraction of new marketing and selling employees* (Equation A-35, Equation A-36).

$$\text{Marketing and selling competence} \qquad \text{Eq A-33}$$
$$= \text{initial marketing and selling competence}$$
$$+ \int (\text{marketing and selling competence improvements}$$
$$- \text{ marketing and selling competence adjustment})$$

$$\text{marketing and selling competence improvements} \qquad \text{Eq A-34}$$
$$= (1/\text{MS years of improvement})$$
$$* \text{ Marketing and selling competence} * (1$$
$$- \text{ Marketing and selling competence})$$

$$\text{marketing and selling competence adjustment} \qquad \text{Eq A-35}$$
$$= (\text{Marketing and selling competence}$$
$$- \text{ new MS employee competence})$$
$$* \text{ fraction of new marketing and sales employees}$$

$$\text{fraction of new marketing and sales employees} \qquad \text{Eq A-36}$$
$$= \text{XIDZ(rate of hiring marketing and selling employees,}$$
$$\text{Marketing and selling employees, 1)}$$

The marketing and selling employees, the rate of hiring, and the adequacy of complementary assets are modelled as part of the firm managing subsystem in Chapter 4. The analyst assesses the initial and new employee competence based on the capability maturity level (see Appendix C). The years of improvement are an input from the venture's annual reports. The effect sizes are derived through automatic model calibration. The strength of the product and value provided by competitors and substitutes are modelled as part of the value creation subsystem in Chapter 4 (for customers) and in this appendix (for users and premium users).

A.3.2.2. Value delivering capabilities

The venture must maintain the customers and users it has acquired through marketing and selling. The lifetime of these depends on the relative product strength and the adequacy of servicing capacity. This capacity has been modelled in Chapter 4 of this thesis. It depends on the venture's employees and the productivity of each employee. This productivity is reflected in their ability to service customers and their ability to service users (Subsection 4.4.5). As with other capabilities, these depend on the competence of employees, the effects of the competence, and the adequacy of complementary assets (Figure A-10).

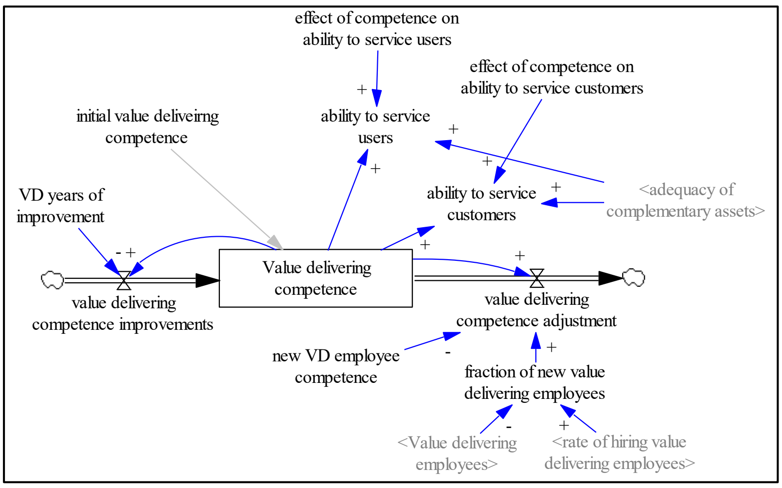


Figure A-10: Value delivering capabilities

The *ability to service customers* and the *ability to service users* reflect the number of indexed customers and users each indexed employee can service. The model multiplies together the *value delivering competence,* the respective *effect of the competence*, and the *adequacy of complementary assets* to derive the abilities (Equation A-37, Equation A-38).

$$\begin{aligned}\text{ability to service customers} &\\ &= \text{Value delivering competence}\\ &* \text{effect of competence on ability to service customers}\\ &* \text{adequacy of complementary assets}\end{aligned} \qquad \text{Eq A-37}$$

$$\begin{aligned}\text{ability to service users} &\\ &= \text{Value delivering competence}\\ &* \text{effect of competence on ability to service users}\\ &* \text{adequacy of complementary assets}\end{aligned} \qquad \text{Eq A-38}$$

The development of the competence follows the same structure as the marketing and selling competence above. It accumulates from its initial value based on improvements and adjustments (Equation A-39). These *value delivering competence improvements* reflect learning and routinisation along the s-curve with the speed of improvement based on the *VD years of improvements* (Equation A-40). The *value delivering competence adjustments* lower the competence towards the *new VD employee competence* depending on the *fraction of new value delivering employees* (Equation A-41, Equation A-42).

$$\begin{aligned}\text{Value delivering competence} &\\ &= \text{initial value deliveirng competence}\\ &+ \int(\text{value delivering competence improvements}\\ &- \text{value delivering competence adjustment})\end{aligned} \qquad \text{Eq A-39}$$

$$\begin{aligned}\text{value delivering competence improvements} &\\ &= (1/\text{VD years of improvement})\\ &* \text{Value delivering competence} * (1\\ &- \text{Value delivering competence})\end{aligned} \qquad \text{Eq A-40}$$

$$\text{value delivering competence adjustment} \qquad \text{Eq A-41}$$
$$= (\text{Value delivering competence} - \text{new value delivering employee competence}) * \text{fraction of new value delivering employees}$$

$$\text{fraction of new value delivering employees} \qquad \text{Eq A-42}$$
$$= \text{XIDZ}(\text{rate of hiring value delivering employees}, \text{Value delivering employees}, 1)$$

The value delivering employees and their hiring rate are modelled as part of the additional details for the firm managing subsystem in this appendix. The analyst sets the initial value delivering competence and years of improvement based on information provided in annual reports (see Appendix C). The effect sizes are determined through automatic model calibration.

A.4. Firm managing subsystem

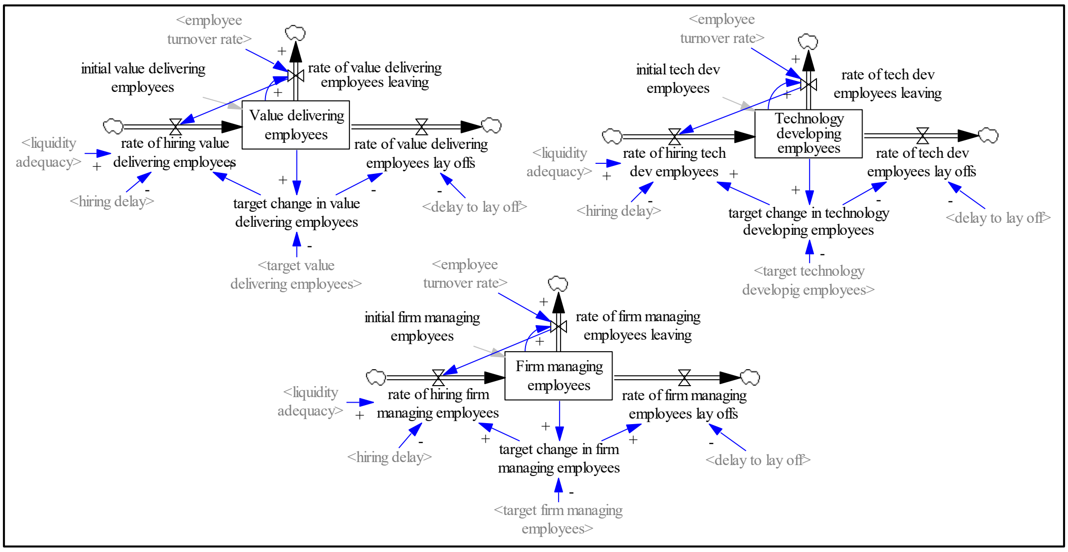
Chapter 4 of the thesis has split the tasks of the firm's management into three categories: managing human resources, managing complementary assets, and managing financial resources. The three subsections below provide further details on these three areas.

A.4.1. Management of human resources

Chapter 4 provided insight into the development of the venture's human resources, the formation of hiring targets, hiring delays, and priorities for employees. The chapter used the venture's marketing and selling employees as an example to illustrate the principles that determine these four elements. However, the model also includes value delivering, technology developing, and firm managing employees. The details for these different employees are outlined below. These details adapt the principles outlined in the main body of the thesis to the specific employee stock and their related activities.

A.4.1.1. Additional employee stocks

The other types of employees considered in the model develop through the same mechanisms as the marketing and selling employees. They increase through hiring and deteriorate through layoffs and employee turnover (Figure A-11). The hiring and layoffs are executed over a delay to adjust the employee numbers to the management's targets. The equations below model employee developments by adapting the structure and equation for marketing and selling employees presented in Chapter 4 (Subsubsection 1.5.1.1).



<u>Figure A-11: Human resource stocks</u>

Each employee stock has an initial value of one. They then accumulate based on their respective hiring, layoff, and leaving rates (Equation A-43, Equation A-44, Equation A-45).

Value delivering employees Eq A-43

$$= \text{initial value delivering employees}$$
$$+ \int (\text{rate of hiring value delivering employees}$$
$$- \text{rate of value delivering employees lay offs}$$
$$- \text{rate of value delivering employees leaving})$$

Technology developing employees Eq A-44

$$\begin{aligned}&= \text{initial tech dev employees}\\&+ \int (\text{rate of hiring tech dev employees}\\&- \text{rate of tech dev employees lay offs}\\&- \text{rate of tech dev employees leaving})\end{aligned}$$

Firm managing employees Eq A-45

$$\begin{aligned}&= \text{initial firm managing employees}\\&+ \int (\text{rate of hiring firm managing employees}\\&- \text{rate of firm managing employees lay offs}\\&- \text{rate of firm managing employees leaving})\end{aligned}$$

The rate at which employees leave the venture depends on the employee stock and the *employee turnover rate* (Equation A-46, Equation A-47, Equation A-48). The turnover rate expresses the fractions of employees that leave the venture per period.

rate of value delivering employees leaving Eq A-46

$$\begin{aligned}&= \text{Value delivering employees}\\&* \text{employee turnover rate}\end{aligned}$$

rate of tech dev employees leaving Eq A-47

$$\begin{aligned}&= \text{Technology developing employees}\\&* \text{employee turnover rate}\end{aligned}$$

rate of firm managing employees leaving Eq A-48

$$\begin{aligned}&= \text{Firm managing employees}\\&* \text{employee turnover rate}\end{aligned}$$

The rate of hiring increases an employee stock when the management aims for a positive *target change* in the respective employee stock. This positive target is achieved over the *hiring delay* and executed depending on the *liquidity adequacy*. In addition, the venture needs to replace employees that it has lost due to churn (Equation A-49, Equation A-50, Equation A-51).

$$\text{rate of hiring value delivering employees} = \text{MAX}(0, \text{target change in value delivering employees} / \text{hiring delay}) * \text{liquidity adequacy} + \text{rate of value delivering employees leaving} \quad \text{Eq A-49}$$

$$\text{rate of hiring tech dev employees} = \text{MAX}(0, \text{target change in technology developing employees} / \text{hiring delay}) * \text{liquidity adequacy} + \text{rate of tech dev employees leaving} \quad \text{Eq A-50}$$

$$\text{rate of hiring firm managing employees} = \text{MAX}(0, \text{target change in firm managing employees} / \text{hiring delay}) * \text{liquidity adequacy} + \text{rate of firm managing employees leaving} \quad \text{Eq A-51}$$

The rate of layoffs decreases an employee stock when the management aims for a negative *target change* in the respective employee stock. This planned reduction in employee numbers is executed over the *delay to lay off* (Equation A-52, Equation A-53, Equation A-54).

$$\text{rate of value delivering employees lay offs} = \text{MAX}(0, -\text{target change in value delivering employees} / \text{delay to lay off}) \quad \text{Eq A-52}$$

$$\text{rate of tech dev employees lay offs} = \text{MAX}(0, -\text{target change in technology developing employees} / \text{delay to lay off}) \quad \text{Eq A-53}$$

$$\text{rate of firm managing employees lay offs} = \text{MAX}(0, -\text{target change in firm managing employees} / \text{delay to lay off}) \quad \text{Eq A-54}$$

Each *target change* expresses the difference between the venture's current indexed employee numbers and the indexed number of employees the venture would like to employ in that activity. This latter target is reflected in the *target value delivering employees, target technology developing employees,* and *target firm managing employees* (Equation A-55, Equation A-56, Equation A-57).

$$\text{target change in value delivering employees} = \text{target value delivering employees} - \text{Value delivering employees} \qquad \text{Eq A-55}$$

$$\text{target change in technology developing employees} = \text{target technology developig employees} - \text{Technology developing employees} \qquad \text{Eq A-56}$$

$$\text{target change in firm managing employees} = \text{target firm managing employees} - \text{Firm managing employees} \qquad \text{Eq A-57}$$

The hiring delay, delay to lay off, and liquidity adequacy have been modelled in the firm managing subsystem in Chapter 4 of this thesis. The sections below describe how the management determines its employee targets across these three different activities.

A.4.1.2. Target value delivering employees

The target value delivering employees expresses how many employees the venture strives to employ for its customer service and content creation activities. Based on Sterman (2000) and Morecroft (2015), Chapter 4 has modelled targets for marketing and selling employees by determining the customer and user acquisition goals and expected acquisitions per employee (Subsubsection 4.5.1.2). These principles have also been applied to value delivering employees. They may service customers, service users, or create content. The number of required employees thus depends on the number of customers and users to service or the content it expects to create, and the expected productivity of each employee in those different tasks (Figure A-12).

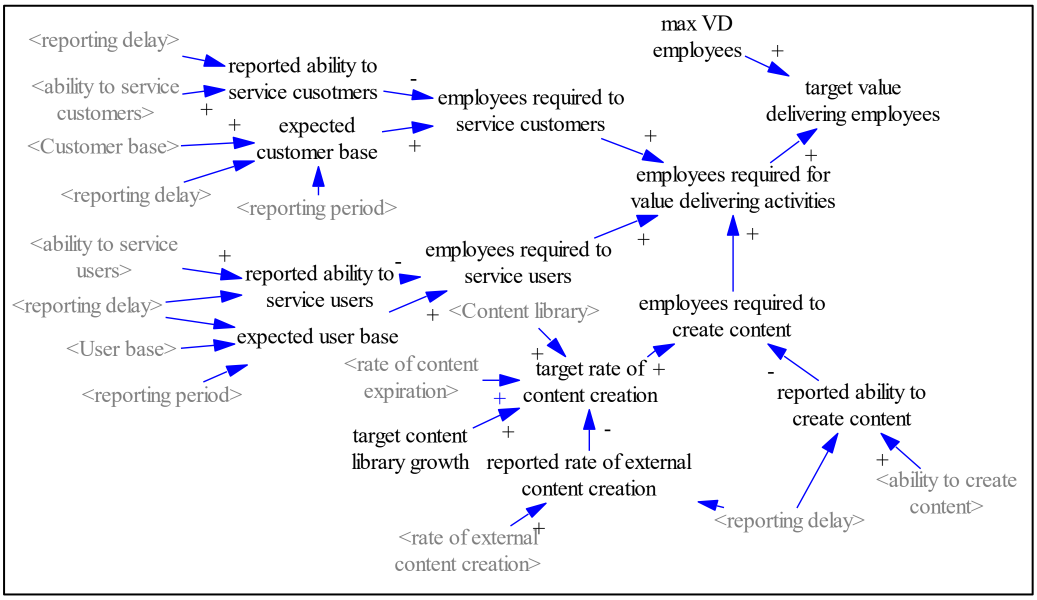


Figure A-12: Target value delivering employees

The venture's *target value delivering employees* depend on the *employees required for value delivering activities* and the venture's *VD employee cap* (Equation A-58). If the venture has not set a cap (-1), the venture will target the number of required employees. Otherwise, the venture will limit the targeted employee number at the cap. The required employees are the sum of those required for each of the possible value delivering activities (Equation A-59).

$$\text{target value delivering employees} = \text{IF THEN ELSE}(\text{VD employee cap} = -1, \text{employees required for value delivering activities}, \text{MIN}(\text{VD employee cap}, \text{employees required for value delivering activities})) \qquad \text{Eq A-58}$$

$$\text{employees required for value delivering activities} = \text{employees required to service customers} + \text{employees required to service users} + \text{employees required to create content} \qquad \text{Eq A-59}$$

The model adapts the goal and requirement formation from marketing and selling activities. For example, the employees required to acquire customers are calculated by determining the number of customers the management wants to acquire and the rate at which it expects each employee to acquire customers (Subsubsection 4.5.1.2). The model implements these principles again. It determines how many customers and users the venture will need to service and how much new content it wants to create. The targets are also affected by the expected productivity of each employee in those tasks (Equation A-60, Equation A-61, Equation A-62).

$$\text{employees required to service customers} = \text{ZIDZ}(\text{expected customer base}, \text{reported ability to service cusotmers}) \quad \text{Eq A-60}$$

$$\text{employees required to service users} = \text{ZIDZ}(\text{expected user base}, \text{reported ability to service users}) \quad \text{Eq A-61}$$

$$\text{employees required to create content} = \text{ZIDZ}(\text{target rate of content creation}, \text{reported ability to create content}) \quad \text{Eq A-62}$$

The *expected customer base* and *expected user base* are determined using Vensim's forecast function. It provides an estimate of the respective base one year ahead (the reporting period). It also acknowledges that the management's information about the change in customer and user bases is delayed by the *reporting delay* (Equation A-63, Equation A-64). The model derives the *target rate of content creation* in the same manner as the target customer and user acquisition rates for marketing and selling employees. It assumes an annual *target content library growth* rate that is part of the management's dominant logic. This is the annual rate at which the management wants to grow its *content library*. However, the venture does not need to create all content items themselves to achieve this goal. Like customers acquired through word-of-mouth, the venture disregards content that it expects to be created externally but needs to replace expired content (Equation A-65).

$$\text{expected customer base} = \text{FORECAST}(\text{Customer base}, \text{reporting delay}, \text{reporting period}) \quad \text{Eq A-63}$$

$$\text{expected user base} = \text{FORECAST}(\text{User base}, \text{reporting delay}, \text{reporting period}) \quad \text{Eq A-64}$$

$$\begin{aligned}\text{target rate of content creation} &= \text{Content library} * \text{target content library growth} \\ &- \text{reported rate of external content creation} \\ &+ \text{rate of content expiration}\end{aligned} \quad \text{Eq A-65}$$

The model acknowledges that the management has no perfect information of current employee productivity levels and the rate at which connect is created externally. Therefore, the model uses Vensim's smooth function, which generates reported abilities and a reported rate of external content creation. These adjust over time to current abilities and rates (Equation A-66, Equation A-67, Equation A-68, Equation A-69).

$$\text{reported ability to service cusotmers} \\ = \text{SMOOTH}(\text{ability to service customers, reporting delay}) \qquad \text{Eq A-66}$$

$$\text{reported ability to service users} \\ = \text{SMOOTH}(\text{ability to service users, reporting delay}) \qquad \text{Eq A-67}$$

$$\text{reported ability to create content} \\ = \text{SMOOTH}(\text{ability to create content, reporting delay}) \qquad \text{Eq A-68}$$

$$\text{reported rate of external content creation} \\ = \text{SMOOTH}(\text{rate of external content creation, reporting delay}) \qquad \text{Eq A-69}$$

The value delivering employee cap is an exogenous influence from the dominant logic set by the analyst. All other inputs to this model part emerge from the customer and user subsystem in Chapter 4 or this appendix.

A.4.1.3. Target technology developing employees

As described in the technology developing subsystem (Section 4.3), the venture's technology developing employees maintain the existing technology and develop new technology. The model adapts the same principles as for all other managerial targets. It determines the employees required for these two goals and the expected employee productivity (Figure A-13). The management may cap the number of technology developing employees depending on their dominant logic.

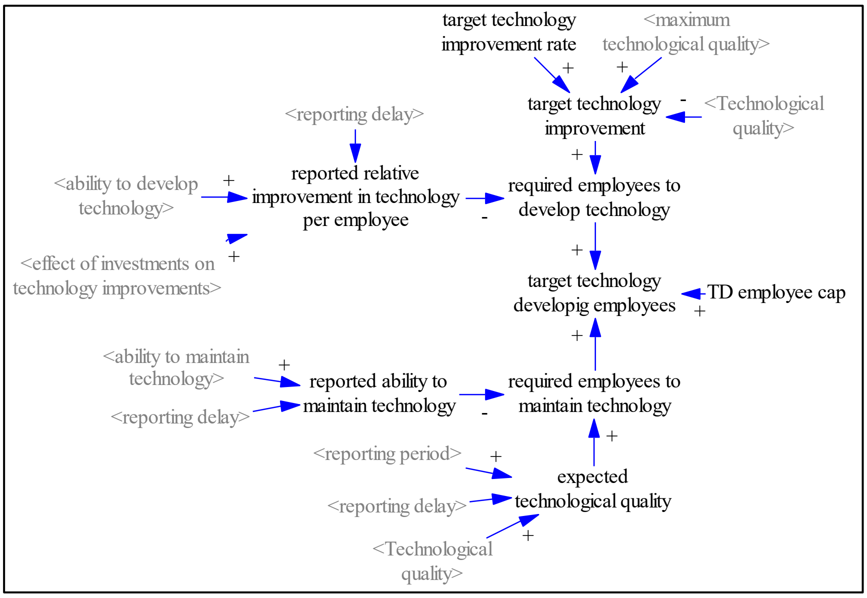


Figure A-13: Target technology developing employees

If the venture has not set a limit for its technology developing employees, the *TD employee cap* variables has a value of -1. In such cases, the venture hires the employees required to maintain and develop its technology (Equation A-70). Otherwise, the venture hires the required employees up to the cap.

$$\text{target technology developig employees} \qquad \text{Eq A-70}$$
$$= \text{IF THEN ELSE (TD employee cap} = -1, \text{required employees to develop technology} + \text{required employees to manage technology}, \text{MIN(required employees to develop technology} + \text{required employees to manage technology}, \text{TD employee cap))}$$

The model calculates the employees required to maintain and develop the venture's technology through the goal these employees need to achieve and their expected employee productivity. As it does for other employee requirements, it divides the goal by the expected employee productivity (Equation A-71, Equation A-72).

$$\text{required employees to maintain technology} \qquad \text{Eq A-71}$$
$$= \text{ZIDZ(expected technological quality, reported ability to maintain technology)}$$

$$\text{required employees to develop technology} = \text{ZIDZ}(\text{target technology improvement}, \text{reported relative improvement in technology per employee}) \quad \text{Eq A-72}$$

The expected employee productivity is expressed by the reported abilities to maintain and develop the technology. As for other reported abilities, it is calculated using Vensim's smooth function (Equation A-73, Equation A-74), which can be used to model expectation formation over a reporting delay (Sterman, 2000).

$$\text{reported ability to maintain technology} = \text{SMOOTH}(\text{ability to maintain technology}, \text{reporting delay}) \quad \text{Eq A-73}$$

$$\text{reported relative improvement in technology per employee} = \text{SMOOTH}(\text{ability to develop technology} * \text{effect of investments on technology improvements}, \text{reporting delay}) \quad \text{Eq A-74}$$

The management also needs to establish its targets in absolute amounts to determine the employees required to maintain and develop the technology. The model calculates the *expected technological quality* that needs maintaining using Vensim's forecast function (Equation A-75). The *target technology improvement* captured the management's improvement target along the technology s-curve. It has been calculated through the remaining improvements on the curve and the *target technological improvement rate*. This rate captures how much of the gap the venture aims to close per year (Equation A-76).

$$\text{expected technological quality} = \text{FORECAST}(\text{Technological quality}, \text{reporting delay}, \text{reporting period}) \quad \text{Eq A-75}$$

$$\text{target technology improvement} = (\text{maximum technological quality} - \text{Technological quality}) * \text{target technology improvement rate} \quad \text{Eq A-76}$$

The two abilities have been calculated as part of the technology developing subsystem in Chapter 4 of this thesis. Readers can find the technological quality and its maximum in the value creation subsystem in Chapter 4 too. The target technological improvement rate is an exogenous input set by the analyst. It reflects the management's dominant logic.

A.4.1.4. Target firm managing employees

Ventures also require firm managing employees that supervise the operating employees. The model treats marketing and selling, value delivering, and technology developing employees as those operating employees. Chapter 3 and 4 argue that firm managing employees are also responsible for developing growth plans and implementing them through hiring, acquiring complementary assets, and raising capital (Section 4.5). A larger number of employees requires additional managerial capacity to supervise and oversee. Therefore, digital ventures growth plans should also include increasing managerial employees (Penrose, 2009). The management must thus form a target for the required firm managing employees. As for other activities, this target depends on the goal these employees must achieve and the expected productivity of firm management employees (Figure A-14).

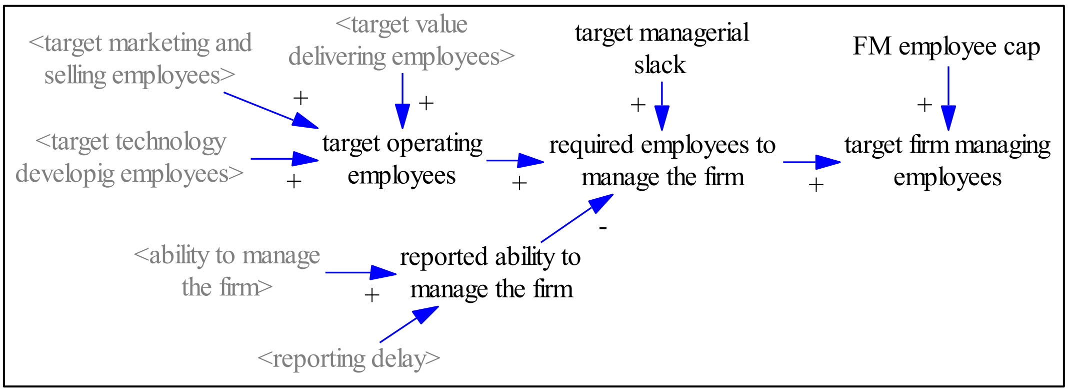


Figure A-14: Target firm managing employees

Like the other employee targets, the management may cap the firm managing employees depending on their dominant logic. If no limit is set, the firm targets the number of required managing employees (Equation A-77). These requirements depend on the number of *target operating employees* the management will need to supervise and the *reported ability to manage the firm*. In addition, the management needs to ensure sufficient managerial slack to hire, acquire complementary assets, and raise capital (Equation A-78). The fraction of additional managerial resources above those required to manage the target operating employees is expressed in the *target managerial slack*. The total number of target operating employees is the sum of the target market and selling employees, target value delivering employees, and target technology developing employees (Equation A-79).

$$\text{target firm managing employees} = \text{IF THEN ELSE}(\text{max FM employees} = -1, \text{required employees to manage the firm}, \text{MIN}(\text{required employees to manage the firm}, \text{max FM employees})) \quad \text{Eq A-77}$$

$$\text{required employees to manage the firm} = \text{ZIDZ}(\text{target operating employees}, \text{reported ability to manage the firm}) * (1 + \text{target managerial slack}) \quad \text{Eq A-78}$$

$$\text{target operating employees} = \text{target marketing and selling employees} + \text{target technology developig employees} + \text{target value delivering employees} \quad \text{Eq A-79}$$

The reported ability to manage the firm expresses how many indexed operating employees each indexed firm managing employee can supervise. It is calculated using Vensim's smooth function that adjusts the reported ability towards the actual ability over the reporting delay (Equation A-80).

$$\text{reported ability to manage the firm} = \text{SMOOTH}(\text{ability to manage the firm}, \text{reporting delay}) \quad \text{Eq A-80}$$

The targets for the operating employee types are modelled in the firm managing subsystem in Chapter 4 of the thesis and this appendix. The ability to manage is modelled with the firm managing capabilities below. The firm managing employee cap is an exogenous influence reflecting the growth state's dominant logic and set by the analyst. The target managerial slack is set to 0.5 for all companies.

A.4.1.5. Further details on target marketing and selling employees

The descriptions of the firm managing subsystem in Chapter 4 of this thesis have outlined how the venture forms targets for its marketing and selling employees.

These included identifying the required employees to acquire the target number of customers, users, and premium users separately. The calculation of these three individual employee requirements was illustrated using the example of the employees required to acquire customers (Subsubsection 4.5.1.2). However, the venture also needs to determine the employees required to achieve its user and premium user growth targets. These two requirements are illustrated here utilising the same structure and equation as illustrated for the customer acquisition requirement. The two individual rates depend on the reported ability of employees to acquire the respective user type and the number of the respective type the venture wants to acquire over the next year (Figure A-15). This absolute number depends on the venture's current users base and the target growth rate. The venture also needs to make up for users lost to churn and those lost to conversion. However, the venture does not need to acquire users through its employees that are acquired through word-of-mouth marketing.

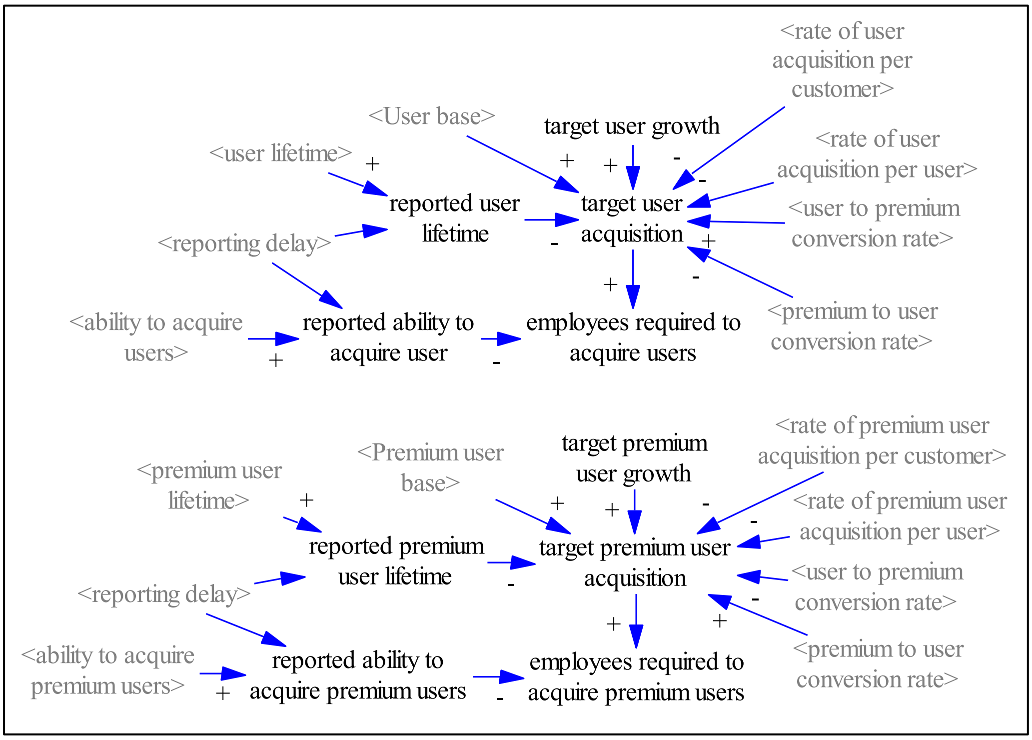


Figure A-15: Target marketing and selling employees

The employees required to acquire users and premium users are calculated by dividing the rate at which the venture strives to acquire users by the rate at which the venture expects each employee to acquire users (Equation A-81, Equation A-82).

$$\text{employees required to acquire users} = \text{ZIDZ}(\text{target user acquisition}, \text{reported ability to acquire user}) \quad \text{Eq A-81}$$

$$\text{employees required to acquire premium users} = \text{ZIDZ}(\text{target premium user acquisition}, \text{reported ability to acquire premium users}) \quad \text{Eq A-82}$$

The reported abilities capture the management's expectations of user acquisition per indexed employee. The model calculates them using Vensim's smooth function that acknowledges the management's delay in determining these abilities (Equation A-83, Equation A-84).

$$\text{reported ability to acquire user} = \text{SMOOTH}(\text{ability to acquire users}, \text{reporting delay}) \quad \text{Eq A-83}$$

$$\text{reported ability to acquire premium users} = \text{SMOOTH}(\text{ability to acquire premium users}, \text{reporting delay}) \quad \text{Eq A-84}$$

The target user and premium user acquisition reflect the number of users and premium users the venture strives to acquire per period to achieve its target growth rates. They depend on the current user and premium user base and the fraction of new users and premium users the venture needs to acquire per period. These fractions are calculated by adjusting the target growth rates for users lost due to churn, users lost due to conversion to other types, users gained due to conversion from other types, and users gained through word-of-mouth marketing (Equation A-85, Equation A-86).

$$\begin{aligned}\text{target user acquisition} &= \text{User base} * (\text{target user growth} \\ &+ \text{ZIDZ}(1, \text{reported user lifetime}) \\ &- \text{rate of user acquisition per customer} \\ &- \text{rate of user acquisition per user} \\ &+ \text{user to premium conversion rate} \\ &- \text{premium to users conversion rate})\end{aligned} \quad \text{Eq A-85}$$

$$\begin{aligned}\text{target premium user acquisition} \\ &= \text{Premium user base} * (\text{target premium user growth} \\ &+ \text{ZIDZ}(1, \text{reported premium user lifetime}) \\ &- \text{rate of premium user acquisition per customer} \\ &- \text{rate of premium user acquisition per user} \\ &- \text{user to premium conversion rate} \\ &+ \text{premium to user conversion rate})\end{aligned} \quad \text{Eq A-86}$$

While the model assumes constant conversion and acquisition rates through word-of-mouth, the customer lifetime adjusts dynamically. However, just as the management does not perfectly know employee abilities, it also does not perfectly know the user lifetimes. Therefore, the management expectation of user lifetimes is determined using the smooth function (Equation A-87, Equation A-88).

$$\text{reported user lifetime} = \text{SMOOTH}(\text{user lifetime}, \text{reporting delay}) \quad \text{Eq A-87}$$

$$\begin{aligned}\text{reported premium user lifetime} \\ &= \text{SMOOTH}(\text{premium user lifetime}, \text{reporting delay})\end{aligned} \quad \text{Eq A-88}$$

The analyst sets the target user and premium user growth rates to reflect the venture's dominant logic in a growth state. All other inputs to these expectations emerge from the customer and user subsystem described in Chapter 4 of the thesis and this appendix.

A.4.1.6. Focus on servicing customers and users and creating content

The venture's value delivering employees may have conflicting priorities and may compromise between servicing users, servicing customers, or creating content. The priorities represent the fraction of time spent on these different tasks (Subsection 4.4.5). Chapter 4 has modelled similar conflicting priorities for marketing and selling employees who may focus on acquiring customers, users, or premium users (Subsubsection 4.5.1.4). The model applies the same structure and equations to derive the foci of value delivering employees. These depend on the fraction of employees required to achieve each value delivering target (Figure A-16).

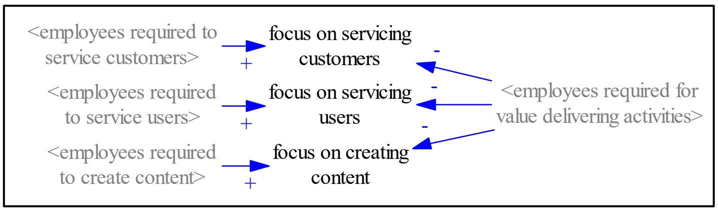


Figure A-16: Focus of value delivering employees

The model calculates each focus by expressing the indexed number of employees required to achieve a goal as a fraction of the indexed total number of required value delivering employees (Equation A-89, Equation A-90, Equation A-91). As outlined in the main body of the text for marketing and selling employees, this gives each focus a value between zero and one. While one indicates that the employees focus all their time on the activity, zero indicates that they do not engage in the activity at all.

focus on servicing customers Eq A-89

= employees required to service customers

/employees required for value delivering activities

focus on servicing users Eq A-90

= employees required to service users

/employees required for value delivering activities

focus on creating content Eq A-91

= employees required to create content

/employees required for value delivering activities

Each value delivering employee requirement has been introduced above.

A.4.2. Management of complementary assets

Chapter 4 of the thesis modelled the adequacy of complementary assets that influences capability levels. This adequacy depends on the complementary assets held by the venture, which depreciate and are acquired by the management. Therefore, the main body of the thesis has modelled acquisition targets and illustrated their implementation (Subsection 4.5.2). The *delay to acquire* *complementary assets* influences the acquisition of complementary assets. It is presented below.

A.4.2.1. Delay to acquire complementary assets

Just as hiring targets are implemented over a hiring delay, the acquisition of complementary assets is delayed by a delay to acquire complementary assets. The model uses the same structure and equation as for the hiring delay (Subsubsection 4.5.1.3). The delay is negatively affected by the number of firm managing employees, their managerial slack, and their ability to invest in complementary assets (Figure A-17). While the firm managing employees and their slack represent the resource inputs to acquiring complementary assets, their ability represents their productivity level. The delay thus implements Sterman's (2000) resource-productivity-flow relationship applied by the model to other activities.

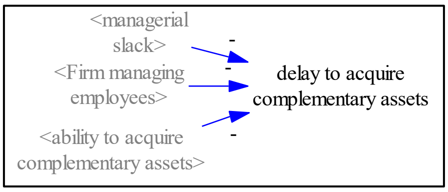


Figure A-17: Delay to acquire complementary assets

The model calculates the delay like the hiring delay by dividing one by the product of the firm managing employees, their managerial slack, and their ability to acquire complementary assets (Equation A-92).

$$\text{delay to acquire complementary assets} = \text{XIDZ}(1, \text{Firm managing employees} * \text{managerial slack} * \text{ability to acquire complementary assets}, 100) \qquad \text{Eq A-92}$$

Please find the model elements for the firm managing employees above, the management's capabilities below, and the managerial slack in Chapter 4 of this thesis.

A.4.3. Management of financial resources

The financial resource management outlined as part of the firm managing subsystem in Chapter 4 includes determining liquidity requirements and raising capital to close liquidity shortfalls. This subsection presents additional details required for the liquidity requirements and the delay to raise capital. They make use of the structures and equations presented in Chapter 4 of this thesis.

A.4.3.1. Additional liquidity requirements

The venture may need to raise additional capital to finance its growth and expansion plans. Chapter 4 has modelled the financing requirements to acquire customers as an example (Subsubsection 4.5.3.3). However, the venture may also need to raise capital to finance its user acquisition, technology improvements, or content creation. As the example presented in the main body of the thesis, these depend on the magnitude of the target, the venture's planning horizon, and the financial resources it wishes to hold per unit of the target (Figure A-18).

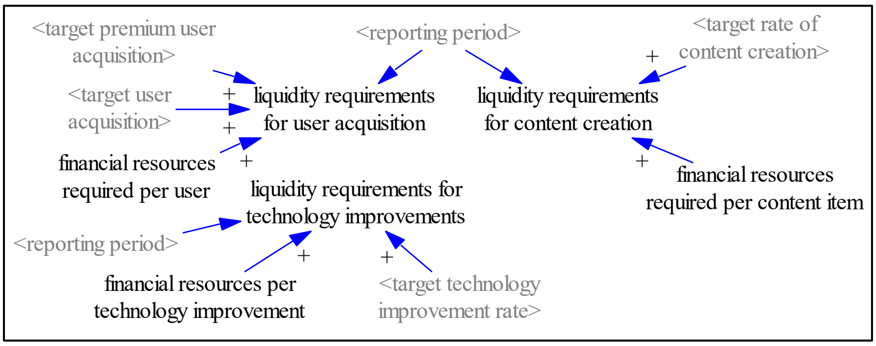


Figure A-18: Additional liquidity requirements

The model adapts the implementation of liquidity requirements in Chapter 4. It calculates each liquidity requirement by multiplying the target rate with the firm's reporting period of one year and the financial resources it aims to hold per unit of the target (Equation A-93, Equation A-94, Equation A-95).

$$\begin{aligned}&\text{liquidity requirements for user acquisition}\\&\quad= (\text{target user acquisition}\\&\quad+ \text{target premium user acquisition})\\&\quad* \text{financial resources required per user}\\&\quad* \text{reporting period}\end{aligned} \qquad \text{Eq A-93}$$

$$\text{liquidity requirements for technology improvements} \qquad \text{Eq A-94}$$
$$= \text{target technology improvement rate}$$
$$* \text{ financial resources per technology improvement}$$
$$* \text{ reporting period}$$

$$\text{liquidity requirements for content creation} \qquad \text{Eq A-95}$$
$$= \text{target rate of content creation}$$
$$* \text{ financial resources required per content item}$$
$$* \text{ reporting period}$$

The user acquisition, technology improvement, and content creation goals were modelled as part of the employee requirements in Chapter 4 of the thesis and this appendix. Automatic model calibration sets the financial resources required per user and technology improvement.

A.4.3.2. Delay to raise capital

Just like the management cannot instantaneously hire and acquire complementary assets, the management can also not raise capital instantaneously. The venture's capital raising is thus delayed (Subsection 4.5.3). Like the previous delays to hire and acquire complementary assets, the delay in raising capital depends on resources available for the activity and the resource's productivity (Sterman, 2000). While the firm managing employees and their managerial slack represent the available resources, their productivity is reflected by their ability to raise capital (Figure A-19).

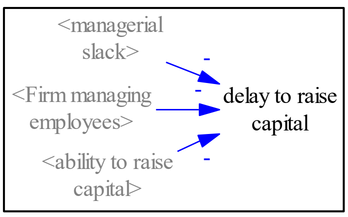


Figure A-19: Delay to raise capital

The model calculates the delay to raise capital by dividing one by the product of the firm managing employees, their managerial slack, and their ability to raise capital (Equation A-96).

$$\text{delay to raise capital} = \text{XIDZ}(1, \text{Firm managing employees} * \text{managerial slack} * \text{ability to raise capital}, 100) \qquad \text{Eq A-96}$$

As described for the delay to acquire complementary assets, the firm managing employees and their capabilities are modelled as part of this subsystem. The managerial slack has been modelled in Chapter 4 of the thesis.

A.4.4. Firm management capabilities

The venture's firm management capabilities affect its capacity to manage employees, and thus the delays to hire, acquire complementary assets, and raise capital. The model uses the same structure and equations used for technology developing employees in Chapter 4 (Subsection 4.3.3) and for customer- and user-related capabilities above. Each ability depends on employee competence, the effect size that transforms the competence to a hard impact on the system, and the adequacy of complementary assets (Figure A-20).

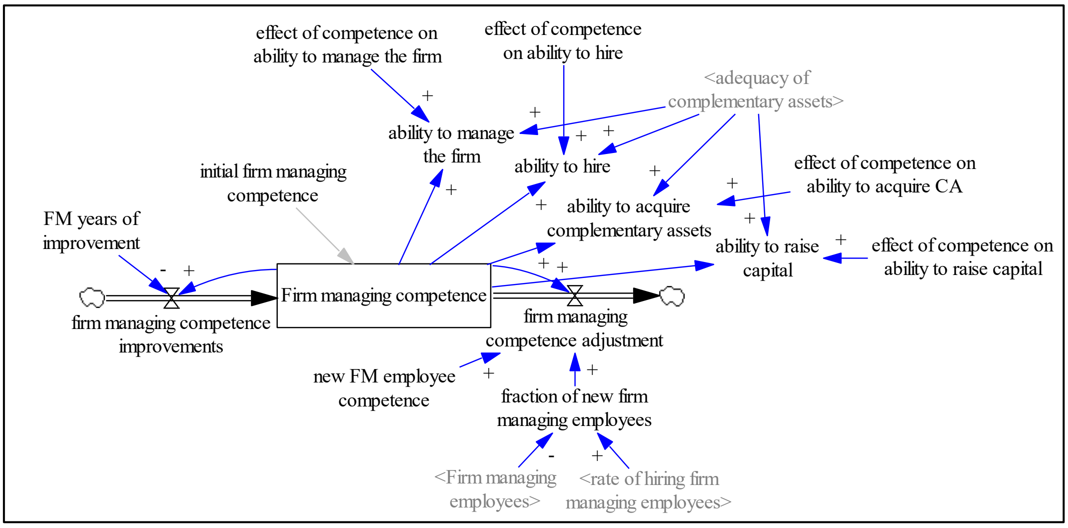


Figure A-20: Firm managing capabilities

The model calculates the four firm managing abilities in the same manner as the other types of capabilities presented in this thesis. It multiplies employee competence with the effect of the competence on the respective ability and the adequacy of complementary assets (Equation A-97, Equation A-98, Equation A-99, Equation A-100).

$$\text{ability to manage the firm} = \text{Firm managing competence} * \text{effect of competence on ability to manage the firm} * \text{adequacy of complementary assets} \quad \text{Eq A-97}$$

$$\text{ability to hire} = \text{Firm managing competence} * \text{effect of competence on ability to hire} * \text{adequacy of complementary assets} \quad \text{Eq A-98}$$

$$\text{ability to invest in complementary assets} = \text{Firm managing competence} * \text{effect of competence on ability to acquire CA} * \text{adequacy of complementary assets} \quad \text{Eq A-99}$$

$$\text{ability to raise capital} = \text{Firm managing competence} * \text{effect of competence on ability to raise capital} * \text{adequacy of complementary assets} \quad \text{Eq A-100}$$

The competence development follows the same structure as the marketing and selling competence and value delivering competencies above and the technology developing competence in Chapter 4 of the thesis. The competence accumulates from its initial value based on improvements and adjustments (Equation A-101). These *firm managing competence improvements* reflect learning and routinisation along Sterman's (2000) s-curve. The speed along this s-curve depends on the *FM years of improvements* (Equation A-102). The *value delivering competence adjustments* lower the competence towards the *new FM employee competence* depending on the *fraction of new firm managing employees* (Equation A-103, Equation A-104).

$$\text{Firm managing competence} = \text{initial firm managing competence} + \int (\text{firm managing competence improvements} - \text{firm managing competence adjustment}) \quad \text{Eq A-101}$$

$$\text{firm managing competence improvements} = (1/\text{FM years of improvement}) * \text{Firm managing competence} * (1 - \text{Firm managing competence}) \quad \text{Eq A-102}$$

$$\text{firm managing competence adjustment} = (\text{Firm managing competence} - \text{new FM employee competence}) * \text{fraction of new firm managing employees} \quad \text{Eq A-103}$$

$$\text{fraction of new firm managing employees} = \text{XIDZ}(\text{rate of hiring firm managing employees}, \text{Firm managing employees}, 1) \quad \text{Eq A-104}$$

The firm managing employees and their hiring rate have been modelled above. The analyst needs to set the initial competence of the firm and the competence of new employees (see Appendix C). The Vensim software calibrates automatically the effect of the competence on the ability to manage. The other effect sizes are fixed for all companies and set to a value of 12. Thus, managers can implement their hiring targets, acquire complementary asset targets, and fundraising targets at fully developed capabilities and managerial slack in one month.

A.5. Content creation subsystem

Some digital ventures employ business models that provide access to content items or artefacts (Afuah and Tucci, 2000; Mikalef, Giannakos and Pateli, 2013; Nambisan, 2017; Nzembayie, Buckley and Cooney, 2019). Examples include online newspapers and streaming services for different types of audio and video content. This thesis has implemented the content quality in the value creation subsystem to account for such business models (see Subsection 4.1.3). The supplementary material for the value creation subsystem in this appendix modelled this quality similar to the technological quality. It formalises the venture’s content library, the quality at which it produces content, and the value of its content assets.

A.5.1. Content library

The *content library* is the collection of all content items that the venture offers to its customers and users (Afuah and Tucci, 2000; Wayne, 2018). It reflects, for example, how many records, videos, or newspaper articles a venture provides. The structure for technological resources is utilised for the content library. If ventures provide content, their initial content library is indexed at one. It then changes through new content creation and content expiration (Figure A-21). While content expires depending on its lifetime, different digital ventures may combine different mechanisms to create additional content. For example, music streaming services generally acquire the rights to external content (Rangaswamy *et al.*, 2020). Newspapers usually publish content that has been created internally by their employed journalists. Other content-based digital ventures may allow their users and customers to create content externally (Zhu and Iansiti, 2007; Naudé and Liebregts, 2009; Mikalef, Giannakos and Pateli, 2013; Gandia and Parmentier, 2017; Zhu and Bao, 2018; Rangaswamy *et al.*, 2020).

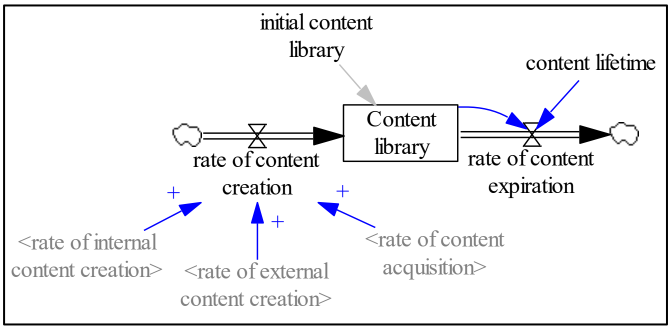


Figure A-21: Content library

The content library accumulates through the *rate of content creation* and *rate of the content expiration* (Equation A-105). Like technological resources' amortisation, the model calculates the expiration rate by dividing the content library by the *content lifetime* (Equation A-106). The rate of content creation is the sum of the *rate of internal content creation*, the *rate of external content creation*, and the *rate of content acquisition* (Equation A-107).

$$\text{Content library} = \text{initial content library} + \int (\text{rate of content creation} - \text{rate of content expiration}) \qquad \text{Eq A-105}$$

$$\text{rate of content expiration} = \text{ZIDZ}(\text{Content library}, \text{content lifetime}) \qquad \text{Eq A-106}$$

$$\text{rate of content creation} = \text{rate of internal content creation} + \text{rate of external content creation} + \text{rate of content acquisition} \qquad \text{Eq A-107}$$

The analyst sets the rate of content acquisition and the content lifetime based on the venture's annual reports. The rates of internal and external content creation are reviewed below.

A.5.1.1. Internal content creation

The rate of internal content creation captures how many content items the venture's value delivering employees create per period (Afuah and Tucci, 2000; Naldi and Picard, 2012). It depends on the venture's employees, their ability to create content, and their focus on creating content (Figure A-22). Like other capabilities, this ability depends on the venture's complementary assets and employee competence level, scaled using an effect variable.

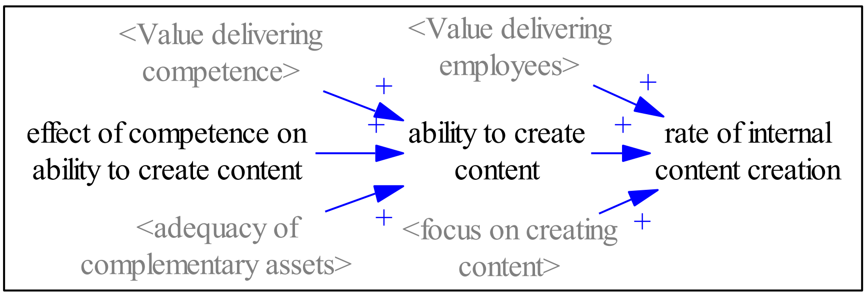


Figure A-22: Internal content creation

The model uses Sterman's (2000) resource-productivity-flow relationship to model employees' *rate of internal content creation*. Like in previous implementations of this relationship, the resources are the number of *value delivering employees* and their *focus on creating content*. The *ability to create content* represents employee productivity i.e. the indexed items each indexed employee creates per period (Equation A-108). The model calculates the *ability to create content* like the other abilities. It scales employees' *value delivering competence* using the *effect of the competence on the ability to create content* and multiplies it with the *adequacy of complementary assets* (Equation A-109).

$$\begin{aligned} &\text{rate of internal content creation} \\ &\qquad = \text{Value delivering employees} * \text{ability to create content} \\ &\qquad * \text{focus on creating content} \end{aligned} \tag{Eq A-108}$$

$$\begin{aligned} &\text{ability to create content} \\ &\qquad = \text{Value delivering competence} \\ &\qquad * \text{effect of competence on ability to create content} \\ &\qquad * \text{adequacy of complementary assets} \end{aligned} \tag{Eq A-109}$$

Other subsystems have provided the details for most of the inputs for this part of the model. The value delivering competence is discussed as part of the customer and user subsystem. The value delivering employees, adequacy of complementary assets, and focus on creating content have been discussed as part of the firm managing subsystem in this appendix. The Vensim software sets the effect of the competence on the ability to create content through automatic model calibration.

A.5.1.2. External content creation

The *rate of external content creation* reflects the number of content items created by customers and users for the venture's library per period. This rate depends on the venture's customer and user bases and the rate at which each customer and user creates content (Figure A-23). Content creation may be limited to some customer types depending on the business model design. Moreover, these different groups may create content at different rates (Zhu and Iansiti, 2007; Naudé and Liebregts, 2009; Gandia and Parmentier, 2017; Rangaswamy *et al.*, 2020).

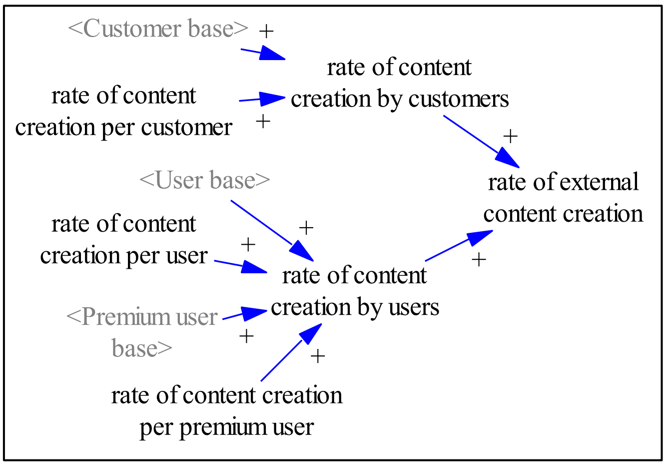


Figure A-23: External content creation

The *rate of external content creation* has been split into the *rate of content creation by customers* and rate *of content creation by users* (Equation A-110). The model calculates the rates at which customers and users create content by multiplying the respective customer and user bases and the rates at which each indexed customer and user creates content (Equation A-111, A-112).

$$\text{rate of external content creation} = \text{rate of content creation by users} + \text{rate of content creation by customers} \quad \text{Eq A-110}$$

$$\text{rate of content creation by customers} = \text{Customer base} * \text{rate of content creation per customer} \quad \text{Eq A-111}$$

$$\text{rate of content creation by users} = \text{User base} * \text{rate of content creation per user} + \text{Premium user base} * \text{rate of content creation per premium user} \quad \text{Eq A-112}$$

The customer and user subsystem derives the number of customers, users, and premium users. The rates of content creation per user or customer are exogenous inputs set by the analyst.

A.5.2. Content quality

The *quality of new content items* reflects the quality of content items currently added to the venture's library. This quality affects the content quality in the value creation subsystem. As new items are added to the content library, the average content quality moves towards the quality of new items. The different mechanisms that add content to the content library may produce content of different qualities. The quality of internally developed content depends on employees' competence to create appealing content. The quality of externally created content depends on the users' experience (Kim, Oh and Shin, 2010; Oestreicher-Singer and Zalmanson, 2013; Kim and Kim, 2017; Täuscher and Abdelkafi, 2018). This experience has been modelled using their usage intensity as a proxy (Figure A-24).

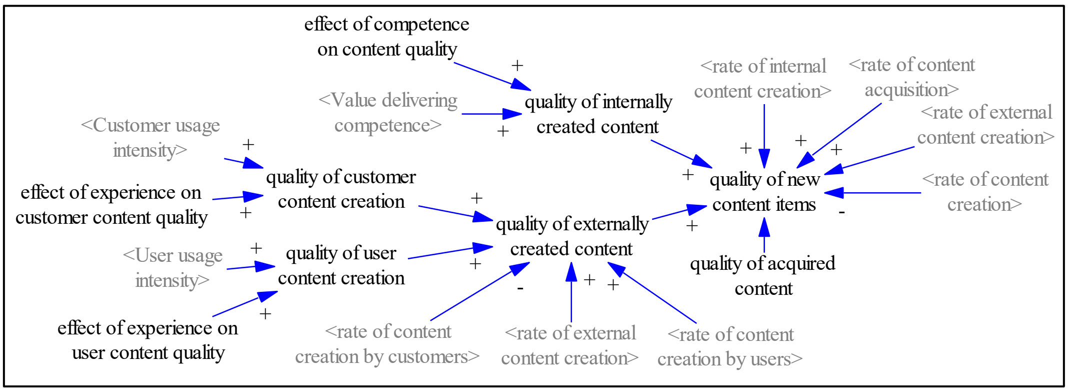


Figure A-24: Quality of new content items

The model weights the different content qualities by their fraction of the total *rate of content creation* (Equation A-113). The model calculates the *quality of internally generated content* based on the value delivering competence. It scales the competence using the *effect of competence on content quality* (Equation A-114).

$$\text{quality of new content items} \qquad \text{Eq A-113}$$
$$= \text{ZIDZ}((\text{quality of internally created content}$$
$$* \text{ rate of internal content creation}$$
$$+ \text{ quality of externally created content}$$
$$* \text{ rate of external content creation}$$
$$+ \text{ quality of acquired content}$$
$$* \text{ rate of content acquisition}), \text{rate of content creation})$$

$$\text{quality of internally created content} \qquad \text{Eq A-114}$$
$$= \text{Value delivering competence}$$
$$* \text{ effect of competence on content quality}$$

The model derives the *quality of externally created content* like the overall quality. It calculates the weighted average of the *quality of customer content creation* and the *quality of user content creation* (Equation A-115). These respective qualities at which customers and users create new content depend on their abilities and experience. The model assumes that this ability develops as customers and users learn how to use the product and its features over time. The value creation subsystem has modelled this experience using the usage intensity. Intensities accumulate as customers become familiar with the product and adopt its features (Subsection 4.1.4). Therefore, the model uses it here to derive the quality at which customers and users create content. Like employee competence, the model scales the usage intensities using the *effect of experience on the content quality* (Equation A-116, Equation A-117).

$$\text{quality of externally created content} \qquad \text{Eq A-115}$$
$$= \text{ZIDZ}((\text{quality of customer content creation}$$
$$* \text{ rate of content creation by customers} + \text{quality of user content creation}$$
$$* \text{ rate of content creation by users}), \text{rate of external content creation})$$

$$\text{quality of customer content creation} \qquad \text{Eq A-116}$$
$$= \text{Customer usage intensity}$$
$$* \text{ effect of experience on customer content quality}$$

$$\text{quality of user content creation} \qquad \text{Eq A-117}$$
$$= \text{User usage intensity}$$
$$* \text{ effect of experience on user content quality}$$

The customer and user subsystem has illustrated the value delivering competence, while the value creation subsystem has illustrated the usage intensities. The effect sizes are set using automatic model calibration.

A.5.3. Content assets

The content library expresses the indexed number of content items that the venture offers to its customers and users. Some digital ventures may also account for this library in monetary terms on their balance sheet as *content assets*. For example, they may purchase or licence content for specified timeframes. They may also create content items themselves that they expect to have a useful life (Afuah and Tucci, 2000; Labes, Erek and Zarnekow, 2013; Rangaswamy *et al.*, 2020). As ventures can capitalise development costs, they may also capitalise investments into bought or internally created content items. Like technological resources, content assets amortise over their lifetime (Figure A-25).

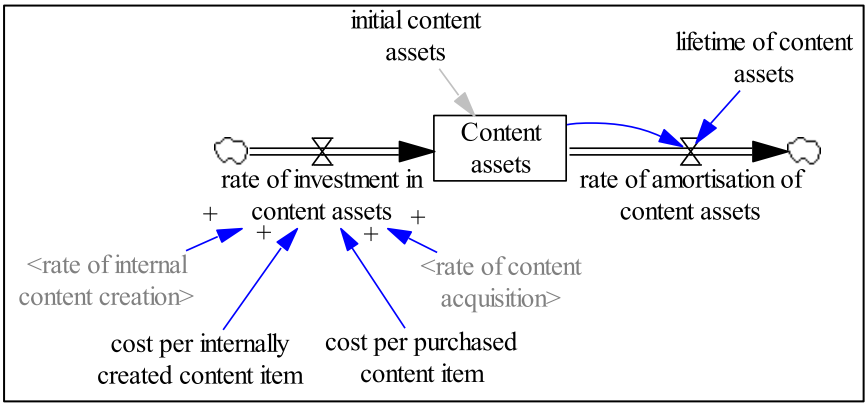


Figure A-25: Content library

The *content assets* accumulate from their initial value through the *rate of investment in content assets* and the *rate of amortisation of content assets* (Equation A-118). The model calculates the amortisation rate similarly to the depreciation and amortisation of complementary assets and technological resources. It divides the stock of content assets by the *lifetime of content assets* (Equation A-119). The model calculates the investment rate by multiplying the indexed number of content items internally created and externally acquired with the respective indexed cost per item (Equation A-120).

$$\text{Content assets} = \text{initial content assets} + \int(\text{rate of investment in content assets} - \text{rate of amortisation of content assets}) \quad \text{Eq A-118}$$

$$\text{rate of amortisation of content assets} = \text{ZIDZ}(\text{Content assets}, \text{lifetime of content assets}) \quad \text{Eq A-119}$$

$$\text{rate of investment in content assets} = \text{rate of internal content creation} * \text{cost per internally created content item} + \text{rate of content acquisition} * \text{cost per acquired content item} \quad \text{Eq A-120}$$

The analyst must set the initial content assets, their lifetime, and the costs per content item. They are based on information contained in the venture's financial statements (see Appendix C).

A.5.4. Overview of subsystem inputs

The content creation subsystem calculates the venture's content library and content assets (Table A-1). These outputs can be compared to annual reports regarding the number of content items offered by a digital venture and their value on its balance sheet. The subsystem relies on inputs from others to derive these stocks. The model covers the development of content through the venture's employees and its customers. Thus, inputs from the firm managing and customer subsystems are required.

Table A-1: Outputs and inputs of the content creation subsystem

<table>
<tr><th colspan="2">Outputs</th></tr>
<tr><td colspan="2">• Content library, content assets</td></tr>
<tr><th>Inputs from other subsystems</th><th>Exogenous inputs</th></tr>
<tr><td>User and customer subsystem:
• Value delivering competence
• Customer base, user base, premium user base
• Customer usage intensity, user usage intensity
Firm management subsystem:
• Value delivering employees
• Focus on content creation
• Adequacy of complementary assets</td><td>Business model design:
• Effect of competence on ability to create content, effect of competence on content quality
• Initial content library
Environment – User and customer behaviour:
• Rate of content creation per customer, rate of content creation per user, rate of content creation per premium user
• Effect of experience on customer content quality, effect of experience on user content quality
Environment – Input providers:
• Cost per internally created content item, cost per acquired content item
• Quality of acquired content
Accounting measures:
• Initial content assets
• Content lifetime, Lifetime of content asset
• Rate of content acquisition</td></tr>
</table>

The content creation subsystem also requires exogenous inputs. These relate to the business model design regarding content as a value driver and the effectiveness of a venture's content creation processes. Other inputs relate to the content creation by customers and the cost of creating content. Finally, accounting measures are required to set the initial stock of content assets, the lifetime of assets, and the rate of content acquisition.

Appendix B: Custom Vensim macros

Vensim macros allow repeating model structures without replicating the stock-and-flow diagrams and retyping the equations. The Vensim software implements many of its functions via macros. Examples of such built-in macros are the smooth or forecast functions used in this thesis (Ventana Systems, no date). In addition to built-in macros, the detailed descriptions of the model in Chapter 4 of the thesis also include two custom macros: the HasValue and the RollingAnnualFinancial functions. The details of these two macros are provided below.

B.1. HasValue

The model uses the HasValue function to calculate the product strength for customers (Subsection 4.1.3) and users (Subsection A.1.2). It shortens the equations used to calculate these product strengths significantly. The product strengths depend on the five value drivers identified for digital ventures. The model multiplies together these value drivers to calculate the product strengths. If a value driver is employed, its initial value is one. If it is not employed, it is zero throughout the simulation. This setup allows identifying if a value driver is not employed and avoids mistaking an unemployed value driver with a constant one. However, using the value of zero in combination with multiplication causes problems when calculating the product strength if one or more value drivers are not employed. In such cases, the multiplication would create product strengths of zero. Therefore, an if-structure must be used to check if a value driver is used and set it from zero to one. This ensures that a value driver does not affect the calculation of the product strength if the value driver is not employed. However, this would create a long equation with five if-clauses.

The HasValue function executes these if-clauses externally to shorten the equations used to calculate product strengths. The function receives a value driver as the variable parameter and the value of one as the output parameter (Macro B-1).

Macro B-1: HasValue

```
:MACRO: HasValue(variable, output)
HasValue=IF THEN ELSE(variable=0, output, variable)
	~	variable
	~		|

:END OF MACRO:
```

If a value driver is employed and thus not zero, the function returns the driver's value. If the value driver is not employed and thus zero, the function returns one to avoid the multiplication of the product strength being erroneous.

B.2. RollingAnnualFinancial

The detailed descriptions of the model in Chapter 4 have outlined conceptual differences between accounting figures and variables representing instantaneous rates in System Dynamics models (Subsections 4.1.5, 4.2.3). Therefore, System Dynamics modellers must also model the reporting system (Sterman, 2000, 2005). The RollingAnnualFinancial function converts the rate variables of System Dynamics models to accounting figures over a reporting period. It has been based on the structure of equations used by Oliva, Sterman, and Giese (2003), who use their implementation to calculate quarterly accounting figures.

The RollingAnnualFinancial function requires two inputs (Macro B-2). The first parameter is a *current rate* in units of money per period reflecting, for example, the rate at which a company generates revenue or incurs costs in the model. The second parameter is the *reporting period* in units of time over which the function should generate the accounting figure. The function's core is a stock named *Rolling accumulation*, which accumulates from its initial value of zero through the *current rate* and a *delayed rate*. This delayed rate is the current rate delayed by the reporting period. Until a reporting period has passed, no outflows of the stocks occur. Thereby, the stock averages the current rate over the reporting period.

Using a stock with an initial value of zero has the disadvantage that estimates are too low until an entire reporting period has passed. Therefore, the RollingAnnualFinancial function also annualises the stock's value. It uses an if-clause checking the time passed in the model. If the model is being initialised (time=0), the function returns the fraction of the current rate appropriate for the reporting period. Otherwise, the function checks if a full reporting period has passed in the model. If it has not, the function annualises the stock. If a full reporting period or more has passed, the function returns the value of the stock.

Macro B-2: RollingAnnualFinancial

```
:MACRO: RollingAnnualFinancial(current rate, reporting period)
RollingAnnualFinancial=IF THEN ELSE(Time$=0, current rate*reporting period, IF THEN
ELSE(Time$<reporting period, ZIDZ(Rolling accumulation, Time$)*reporting period,
Rolling accumulation))
	~	$
	~		|

Rolling accumulation= INTEG (
	current rate-delayed rate,
		0)
	~	$
	~		|

delayed rate=
	DELAY FIXED(current rate, reporting period, 0)
	~	$/Year
	~		|

:END OF MACRO:
```

Overall, the function provides a flexible approach to convert instantaneous rate variables to accounting figures. The source code can be copied into the Vensim text editor (requires advanced Vensim versions) and used in future models for any accounting variable and reporting period.

Appendix C: Overview of model inputs

The model developed in this thesis and its subsystems rely on a series of inputs. The detailed model developed chapter (Chapter 4) has grouped these inputs into multiple categories. Moreover, each subsystem calculates one or more variables as its outputs. The tables at the end of each subsystem have summarised these exogenous inputs and subsystem outcomes. The methodology chapter has outlined the principles of setting System Dynamics models' hard, soft, and automatically calibrated inputs. The overviews below illustrate all variables and their estimation techniques using those principles. This appendix first outlines the outcomes of each subsystem. It then illustrates how an analyst can set hard and soft variables based on qualitative and quantitative company data. The third section outlines the tests performed on automatically calibrated variables. Some variables have been assigned fixed values across all companies. The final section of this appendix illustrates these variables.

C.1. Subsystem outcomes

Chapter 5 of this thesis has compared the model's subsystem outcomes to historical case data to validate the model. As illustrated in the methodology section, these outputs are hard variables. Thereby, they can be estimated with only minimal transformation and avoid researchers' bias and subjective assessment. Table C-1 illustrates the transformations required before importing the data to the model for comparison and validation.

Table C-1: Measurement of subsystem outcomes

Output	SubS[30]	Estimation
Rolling annual revenue	CR	• Estimated by indexing the annual revenue on the venture's income statement by the initial total assets and the value creation scale using the MonetaryScaler. • Revenue in year / Initial total assets * MonetaryScaler
Rolling annual return on assets	CA	• Estimated by dividing the venture's annual net income on its income statement by, respectively, its total assets

[30] Indicates the subsystem that utilises the variables: value creation (CR), value capture (CA), technology development (TD), customer and user (CU), firm management (FM), and content creation (CC).

Rolling annual net profit margin	CA	on its balance sheet or revenue on its income statement in the same year. • Net income in year / Total assets in year • Net income in year / Revenue in year
Technological resources	TD	• Estimates by indexing the venture's capitalised development expenses on its balance sheet by its initial total assets and the MonetaryScaler. • Some companies may provide an aggregate figure for intangible assets on their balance sheet. In such cases, the notes on the financial reports provide a break-up of intangibles that should include a line item for capitalised development expenses. • Capitalising development expenses is an optional accounting procedure. Companies that do not capitalise software development expenses have been excluded. Without capitalised expenses resources, no measurement of technological resources exists. • Capitalised development costs / Initial total assets * MonetaryScaler
Customer base	CU	• The sum of all customer and user bases needs to be initialised with one to index value creation • If only one type of customers/users is used calculate by customers in year / initial customer base • If customers and users are used, initialise customer and user at 0.5 respectively. If user and premium user are used ensure they are proportional to real data.
User base	CU	
Premium user base	CU	
Marketing and selling employees	FM	• The initial number of employees in an activity indexes each employee stock. Thus, each stock has a value of one in the first year. • If a venture does not initially employ a type of employee, the stock is indexed by the first year in which it employs the type (only applies to Alpha's value delivering employees). • MS employees in year / Initial MS employees • VD employees in year / Initial VD employees • TD employees in year / Initial TD employees • FM employees in year / Initial FM employees
Value delivering employees	FM	
Technology developing employees	FM	
Firm managing employees	FM	
Complementary assets	FM	• Complementary assets are the venture's property, plant, and equipment in addition to its intangible assets, excluding capitalised development expenses and content assets. • Initial total assets and the MonetaryScaler index them. • (PPE + Intangibles – development expenses and content assets in year) / Initial total assets * MonetaryScaler
Financial resources	FM	• The venture's financial resources are the cash and equivalents on its balance sheet. • Initial total assets and the MonetaryScaler index them • Cash and equivalents in year / Initial total assets * MonetaryScaler
Equity employed	FM	• The venture's equity employed is the share capital and additional paid-in capital on the venture's balance sheet. • Initial total assets and the MonetaryScaler index the equity. • (Share capital + Additional paid in capital in year) / Initial total assets * MonetaryScaler
Debt employed	FM	• The venture's debt employed is the long-term debt on its balance sheet. • Initial total assets and the MonetaryScaler index the

		debt. • Long-term debt in year / Initial total assets * MonetaryScaler
Content assets	CC	• Its content assets are intangible assets on the venture's balance sheet reflecting the capitalised costs of content production and acquisition. Initial total assets and the MonetaryScaler index these. • Like technological resources, content assets may be part of an aggregated intangibles figure on the balance sheet with a line item provided in the corresponding note. • Companies not employing content-based business models have no content assets. Its value is thus zero throughout the simulation. • Value of content assets in year/ Initial total assets * MonetaryScaler
Content library	CC	• The size of the content library is estimated based on the number of content items offered by the venture. • Analysts may use different data points depending on the type of content offered. Examples include the number of songs, videos, or articles; or the total duration of songs or videos. • Companies not employing a content-based business model do not have a content library. Its value is thus zero throughout the simulation. • Number of content items in year / Initial number of items

C.2. Manually set variables

Each subsystem's summary table has categorised the inputs analysts must set. These categories are outlined below with all variables included in them. For each variable, the estimation techniques based on qualitative and quantitative information in annual reports are illustrated. The list provided in this section is extensive. However, many variables reflect different input settings to reflect different business models that can quickly be set to, for example, zero or one. Moreover, many variables in the model exist multiple times. For example, the model uses the same structures for users and customers. It also uses the same structures for all four different employee types and capabilities. The inputs to these replicated structures are derived in the same manner. Therefore, the model is much less driven by exogenous influences as this detailed list would indicate.

C.2.1. Business model design

Chapter 4 shows digital ventures' business models. For example, some digital ventures may employ freemium business models, some rely on network effects, and some are content-based. These different business models have been implemented in the model using policy switches (Coyle, 1996). The analyst needs to set up the model to account for these different business model designs (Table C-2).

Table C-2: Measurement of business model design inputs

Input	SubS	Estimation
Premium product advantage	CR	• Assessed by the analyst by reviewing the premium product's features compared to the base product. • Where available, quantitative information should be preferred to avoid bias. For example, the number of content or features free and paid to view and use. • Set to zero if the venture does not differentiate between users and premium users
Maximum technological quality	CR	• Assess by reviewing the nature of changes in the venture's technology over the investigation period: • 1.2 for ventures that do not make any significant changes to their technology and have a very mature technology. The initial technological quality is always set as one. Therefore, this allows a 20% increase in the venture's technology along the s-curve. • 1.5 for ventures that have an established to mature technology but significantly improved their offer to customers. • >2 for new companies with a minimum viable product and significant improvements.
Customer direct network effect settings	CR	• Each variable is set based on reviewing the venture's business model: • 0 for business models that do not provide value via the respective network effects. For example, because the venture does not distinguish between different user and customer groups. • 1 for business models that make use of the respective network effect. For example, when offering a marketplace or social network. • -1 for business models with negative network effects, for example, to reflect increasing competition on marketplaces.
customer indirect network effect settings	CR	
User direct network effect settings	CR	
User indirect network effect settings	CR	
Customer contract period	CA	• The contract periods in years are set based on information provided on the venture's website and annual reports.
Premium user contract period	CA	
Initial content quality	CR	• Both variables are indexed at an initial value of 1 if employed; both variables are zero if they are not employed by a venture
Initial content library	CC	

C.2.2. Environment

The model also requires inputs regarding the venture's external environment. These relate to the different stakeholder groups that the model considers. The first set of inputs relate to customer and users. They include their initial values, the value they derive from using the product, and their behaviour regarding word-of-mouth and content creation (Table C-3).

Table C-3: Measurement of customer and user inputs

Input	SubS	Estimation
Initial customer base	CU	• The initial values of the inputs that are determined in the performance outcomes section (see Table C-1).
Initial user base	CU	
Initial premium user base	CU	
Initial customer usage intensity	CR	• One if the venture services the type; zero if the venture does not service it.
Initial user usage intensity	CR	
New customer usage intensity	CR	• Set to reflect the development of usage-intensity variables (e.g. each user's features used, content consumed, transactions facilitated,…): • Maximum set just above the maximum of the development curve observed. • New intensity set just below the minimum of the curve. • Adoption rate set to fit the curve's development in the model to historical data. • Values are zero if a venture does not service the respective customer/user type.
New user usage intensity	CR	
Maximum customer usage intensity	CR	
Maximum user usage intensity	CR	
Standard rate of adoption by customers	CR	
Standard rate of adoption by users	CR	
User to premium conversion rate	CU	• Zero if the company does not distinguish between users and premium users. • Set based on the conversation rates provided by companies. • If not provided, estimate based on publicly available information for similar products.
Premium to user conversion rate	CU	
Rate of user acquisition per user	CU	• Set based on the acquisition rates provided by companies. • If not provided, estimate based on publicly available information for similar products. • Values are zero if the venture does not highlight word-of-mouth as a customer acquisition channel.
Rate of user acquisition per customer	CU	
Rate of premium user acquisition per user	CU	
Rate of premium user acquisition per customer	CU	
Rate of customer acquisition per user	CU	
Rate of customer acquisition per customer	CU	
Rate of content creation per customer	CC	• Estimated by dividing the indexed number of content items produced by the average indexed number of customers/users. • Indexed number of content produced in year / Average indexed number of users and customers • Use the average value throughout a growth state. Values are zero if customers and users do not create content for the venture.
Rate of content creation per user	CC	
Rate of content creation per premium user	CC	

The second set of environmental inputs relates to the venture's competitors and substitutes (Table C-4).

Table C-4: Measurement of competitor inputs

Input	SubS	Estimation
Strength of competitors and substitutes	CA	• Expresses the strength of the average competitor's product or substitute relative to the venture's product: • 0 if there are no competitors or substitutes • Between 0 and 1 if competitors' products are inferior • 1 if competitors offer products of about equal quality • Greater than 1 if competitors' products are superior • Each year's value is imported into the model
Number of competitors and substitutes	CA	• Based on the market characteristics outlined by (Lipczynski and Wilson, 2004; Grant, 2016), the following values have been set: • 0 for ventures operating in a monopoly • 0.25 for ventures operating in an oligopoly • 1 for ventures operating under perfect competition • Each year's value is imported into the model

The third set of environmental inputs relates to the venture's costs for its different activities, its cost of capital, and the costs per content item (Table C-5).

Table C-5: Measurement of input provider inputs

Input	SubS	Estimation
Cost of value delivering inputs	CA	• Express the indexed annual expenses (wages and other costs) per indexed employee. • (Respective cost in year on the income statement / Initial total assets * Monetary scaler) / (Respective average employees at beginning and end of year) • Values are held constant at the average cost in a growth state.
Cost of marketing and selling inputs	CA	
Cost of technology developing inputs	CA	
Cost of firm managing inputs	CA	
Cost of equity	CA	• Express the respective annual percentage cost of capital. • Respective cost in year on income or cash flow statement / Average of respective capital at beginning and end of year • Values are held constant at the average cost in a growth state.
Cost of debt	CA	
Cost per internally created content item	CC	• Express the indexed expenses or investment per indexed content item. • (Respective cost or investment in year on cash flow statement / Initial total assets * Monetary scaler) / (Indexed produced or acquired content items in year) • Values are held constant at the average cost in a growth state.
Cost per acquired content item	CC	
Quality of acquired content	CC	• Set by the analyst to reflect the relative quality of acquired content to the venture's initial content quality.

Lastly, the analyst needs to evaluate the strength of complementary products that integrate with the venture's technology and offer (Table C-6).

Table C-6: Measurement of complementary product inputs

Input	SubS	Estimation
Complementary quality	CR	• The initial value is always one if complementary products contribute to the value provided by the venture. The variable is zero throughout the simulation if complementary products do not add value to the venture's offer. • The quality of complementary products is assessed annually relative to the initial value. For example, a value of 1.2 would indicate that the average complementary product is 20% better than at the simulation's start.

C.2.3. Dominant logic

The dominant logic captures the management's goals and ambitions for the venture and what is required to succeed (Prahalad and Bettis, 1986; Von Krogh, Erat and Macus, 2000; Levie and Lichtenstein, 2010). The first element of the dominant logic relates to management targets and employee limits. The analyst needs to set these for each growth state (Table C-7).

Table C-7: Measurement of target and limit inputs

<table>
<tr><th>Input</th><th>SubS</th><th>Estimation</th></tr>
<tr><td>Target customer growth</td><td>FM</td><td rowspan="4">• Use the management growth's goals if provided in advance.
• Assume achieved growth rates have been targets if the management provides no goals in advance.
• Use the state's average growth rates (excluding negatives).</td></tr>
<tr><td>Target user growth</td><td>FM</td></tr>
<tr><td>Target premium user growth</td><td>FM</td></tr>
<tr><td>Target content library growth</td><td>FM</td></tr>
<tr><td>Target technology improvement</td><td>FM</td><td>• Reflects the fraction of target improvements on the s-curve[31]:
• 0 if the company does not plan any improvements
• 0.1 if the company plans minor improvements
• 0.2 if the company plans major improvements
• 0.4 if technology improvements are the company's main priority</td></tr>
<tr><td>Max MS employees</td><td>FM</td><td rowspan="4">• Set to -1 if the company does not have any employee limits.
• Set to the number of indexed employees at which the company stabilises. Use the highest indexed number in case of small fluctuations.</td></tr>
<tr><td>Max VD employees</td><td>FM</td></tr>
<tr><td>Max TD employees</td><td>FM</td></tr>
<tr><td>Max FM employees</td><td>FM</td></tr>
</table>

[31] After reviewing the s-curves provided by Christensen (1992) and Nikula *et al.* (2010), these values for different improvement rates have been selected. In their empirical investigations of hardware and software innovations, these authors found improvements of up to 40-50% of the remaining s-curve per year. This maximum has been selected as the highest value for technology improvement targets.

The analyst must also set the initial employee levels (Table C-8). These are the initial values determined in the subsystem outcome section above. Besides, the analyst needs to set the employee turnover rate.

Table C-8: Measurement of human resource inputs

Input	SubS	Estimation
Initial marketing and selling employees	FM	• The initial values of the inputs that are determined in the subsystem outcomes section above (see Table C-1).
Initial value delivering employees	FM	
Initial technology development employees	FM	
Initial firm managing employees	FM	
Employee turnover rate	FM	• Use company provided figures if provided (average over the investigation period or growth states). • If not provided[32]: • 20% for companies with normal turnover • 30% for companies with high turnover and adverse employee relationships

The final selection of dominant logic variables relates to the firm's complementary assets and financial resource requirements (Table C-9). These can be approximated based on the ventures assets stocks and fundraising efforts.

Table C-9: Measurement of asset requirement inputs

Input	SubS	Estimation
Complementary assets required per employee	FM	• Estimated by calculating the complementary assets per total indexed employees. Initial total assets and MonetaryScaler index complementary assets. • (Complementary assets / Initial total assets * MonetaryScaler) / Total indexed employees • Use the average of the investigation period/growth state.
Financial resources required per customer	FM	• If the venture has only one goal, these can be estimated by dividing the indexed capital raised per magnitude of the goal. For example: • (Customer base * Target growth rate) / (Capital raised / Initial total assets * MonetaryScaler) • If the venture has multiple goals, it may be unclear which goal caused the fundraising. In such cases, automatic model calibration
Financial resources required per user	FM	
Financial resources required per technology improvement	FM	

[32] Reported turnover rates in digital ventures vary widely. While the overall technology industry has turnover rates of around 15%, averages of 20-25% per year have been reported for new ventures (Founders Circle Capital, no date; Power, 2018; Bean, 2019). Therefore, the normal turnover rate has been set at 20% to reflect the average of these reported turnover rates.

Financial resources required per content item	FM	can be used. The values must be positive (feasible) and in the same order of magnitude but likely lower than each estimation (consistency).
Equity debt preference	FM	• Estimated by dividing each year's equity raised by the total of equity and debt raised. • Equity raised in year / (Equity raised in year + debt raised in year) • Import each year's figure into the model.
Fraction of equity repurchased	FM	• Estimated by dividing the equity or debt repaid in a year by average equity and debt at the beginning and end of the year. • Equity repurchased in year / Average equity • Debt repaid in year / Average debt • Import each year's figure into the model.
Fraction of debt repaid	FM	

C.2.4. Capability development

The four capabilities modelled in Chapter 4 of the thesis each develop from their initial levels based on their improvement times and new employee capabilities. The analyst needs to set these based on qualitative information in annual reports (Table C-10).

Table C-10: Measurement of capability development inputs

Input	SubS	Estimation
Initial marketing and selling competence	CU	• Capabilities have values between zero and one. The model divides this scale into the five levels of the capability maturity levels (Paulk *et al.*, 1993): • 0.1 when the activity is performed on an ad hoc basis • 0.3 when the activity is executed on a repeatable but reactive basis • 0.5 when the processes and routines are defined and integrated • 0.7 when the activities are managed and controlled • 0.9 when the routines have been continuously improved
Initial value delivering competence	CU	
Initial technology developing competence	TD	
Initial firm management competence	FM	
New MS employee competence	CU	• Assessed on the same capability maturity scale as the initial capabilities above. • Only the 0.1 and 0.3 values should be used as new employees cannot be integrated yet by definition.
New VD employee competence	CU	
New TD employee competence	TD	
New FM employee competence	FM	
MS years of improvement	CU	• Use (maximum) training times if provided by the venture. • Otherwise set to reflect the knowledge of capability improvements of the venture
VD years of improvement	CU	
TD years of improvement	TD	

FM years of improvement	FM	over time. • If unknown, set training times based on similarly mature firms.

C.2.5. Accounting measures

The model also relies on some imported accounting measures (Table C-11). Some accounting measures initialise the model's stocks. Other inputs, like other assets and taxation, ensure consistency of variables when validating the model while not being theoretically relevant. This latter group relies on complex rules and discretionary decisions, for example, depreciation schedules. These are out of the model's scope.

Table C-11: Measurement of accounting inputs

Input	SubS	Estimation
Other assets	CA	• Reflect all assets recognised on the firm's annual balance sheet but not included in the model. • Calculated by indexing each year's total assets by initial total assets and the MonetaryScaler. Assets included in the model (see performance outcomes) are then subtracted. • Total assets in year / Initial total assets * MonetaryScaler – Technological resources in year – Financial resources in year – Complementary assets in year – Content assets in year
Rolling annual taxation	CA	• Reflect the taxes paid (or tax credit received) by the venture in a given year. • Taxes paid are a positive number. Taxes credits received are a negative number. • Calculated by indexing each year's taxes on the venture's income statement by initial total assets and the MonetaryScaler. • Taxes in year / Initial total assets * MonetaryScaler
Initial technological resources	TD	• The initial values of the inputs that are determined in the performance outcomes section (see Table C-1).
Initial financial resources	FM	
Initial complementary assets	FM	
Initial equity employed	FM	
Initial debt employed	FM	
Initial content assets	CC	
Lifetime of technological resources	TD	• Each year's lifetime is calculated by dividing the stock's average value (at the beginning and end of a year) by the loss during a year. • If the venture does not employ a content-based business model, the lifetime of content items and assets is zero throughout the simulation. • Average technological resources at beginning and end of year / Amortisation of tech resources in year • Average complementary assets at beginning and end of year / Depreciation of comp assets in year • Average content assets at beginning and end of
Lifetime of complementary assets	FM	
Lifetime of content asset	CC	

Content lifetime	CC	year / Amortisation of content assets in year • Average number of content items at beginning and end of year / Loss of content items in year
Rate of content acquisition	CC	• The value of content items purchased in a year, indexed by initial total assets and the MonetaryScaler. • Like the investment in technological resources, the acquisition can be found on the venture's annual cash flow statement. • It is zero throughout the simulation if the venture does not employ a content-based business model or purchases no content. • Value of content acquisition per year / Initial total assets * MonetaryScaler

C.3. Automatically calibrated variables

The model also determines some input values using the Vensim software's calibration features. The software determines variable values by identifying inputs that maximise the model's fit to data for other variables. This process is commonly used in System Dynamics when no data is available to set input values manually, particularly for variables required for specific structures. In the model, these structures relate to three types of variables: standard rates, effect sizes, and the MontaryScaler. Calibration is an established process and critical for testing the model's ability to replicate the behaviour of a system (Lyneis and Pugh, 1996; Oliva, 2003, 2004; Homer, 2012). To ensure the reliability of the automated process, Oliva (2003) recommends confirming variables' feasibility and consistency (see subsection 2.4.1.2 of the methodology chapter for details). The automatically calibrated variables and their test are illustrated below. The first group of automatically calibrated variables relates to standard rates and effects (Table C-12). The model adjusts these variables as part of Sterman's (2000) multiplicative effects structure or s-curve.

Table C-12: Automatically calibrated standard values

<table>
<tr><th>Input</th><th>SubS</th><th>Validation</th></tr>
<tr><td>Standard customer lifetime</td><td>CU</td><td rowspan="2">• Feasibility: Values need to be positive. No negative lifetimes are possible.
• Consistency: While customer and user lifetimes in a digital context differ widely, they can generally be assumed to be between two and eight years. Unless otherwise stated by the company, these values should be confirmed for the model’s standard and adjusted lifetimes.</td></tr>
<tr><td>Standard user lifetime</td><td>CU</td></tr>
<tr><td>Standard effect of investment in technology on technological improvement</td><td>CR</td><td>• Feasibility: Values need to be positive. No negative effect is possible.
• Consistency: The variable transforms investments into technology into improvements in technological quality. The development of the technological quality in the model should reflect qualitative statements about product changes in annual reports.</td></tr>
</table>

The second group of automatically calibrated variables relates to the effect sizes that transform employee competencies from a soft scale between zero and one to a hard impact on the system (Table C-13). These effect sizes are part of Warren’s (2002) capability structure adopted in the model and reflect a business model’s activity throughput at fully developed capabilities.

Table C-13: Automatically calibrated effect sizes

<table>
<tr><th>Input</th><th>SubS</th><th>Validation</th></tr>
<tr><td>Effect of competence on ability to acquire customers</td><td>CU</td><td rowspan="9">• Feasibility: Values need to be positive. No negative effects are possible.
• Consistency: The analyst should compare variable values to approximations of the effect size. For example:
• Indexed customers acquired in period / Average number of indexed MS employees at beginning and end of year / Estimated focus of employees / Initial marketing and selling competence
• Indexed customers in year / Number of indexed VD employees in year / Estimated focus of employees / Initial value delivering competence
• Indexed customers in year / Number of indexed VD employees in year / Estimated focus of employees / Initial value delivering competence
• Indexed investment in technology in period / Average number of TD employees at beginning and end of year / Initial technology developing competence
• Indexed number of operating employees in year * (1+Mangerial Slack) / Average number of FM employees / Initial firm managing competence
• Indexed content items created in period / Average number of indexed VD employees at beginning and end of year / Estimated focus of employees / Initial value delivering competence</td></tr>
<tr><td>Effect of competence on ability to acquire users</td><td>CU</td></tr>
<tr><td>Effect of competence on ability to acquire premium users</td><td>CU</td></tr>
<tr><td>Effect of competence on ability to service customers</td><td>CU</td></tr>
<tr><td>Effect of competence on ability to service users</td><td>CU</td></tr>
<tr><td>Effect of competence on ability to develop technology</td><td>TD</td></tr>
<tr><td>Effect of competence on ability to maintain technology</td><td>TD</td></tr>
<tr><td>Effect of competence on ability to manage employees</td><td>FM</td></tr>
<tr><td>Effect of competence on ability to create content</td><td>CC</td></tr>
</table>

Effect of competence on content quality	CC	• *Feasibility*: Values need to be positive. No negative effects are possible. • *Consistency*: These variables affect the development of content quality. The development of the content quality should reflect the statements made in annual reports.
Effect of experience on customer content quality	CC	
Effect of experience on user content quality	CC	

The model indexes many hard variables to obscure the identity of case companies. Thereby, it transforms them from variable scales of absolute numbers to a reference point. This reference point is usually the initial value of a variable. For example, the model expresses the marketing and selling employees at any year relative to the venture's initial marketing and selling employees. Thereby, the stock in the model has an initial value of one. If the venture's employees increase from 50 to 55 employees over the first year, the model shows an increase from 1 to 1.1. This indexing also applies to all monetary amounts and rates. The reference point for revenues, costs, and assets owned by the venture is the initial rate of value creation of 1. In the above setting, monetary values are transformed to this scale by initial total assets and the MonetaryScaler. Indexing monetary values by initial assets already obscures companies' identities. The MonetaryScaler then transform the indexing from the initial total assets scale to the value creation scale (Table C-14). This is required to ensure that all monetary values in the model can be used in calculation while treating value creation as an indexed qualitative variable. This rescaling is executed through automatic model calibration after using the assets-indexed values as input (see Chapter 5 and Appendix D).

Table C-14: Automatically calibrated monetary scale adjustment

Input	**Validation**
MonetaryScaler	• *Feasibility*: Values need to be positive. No negative scaler is possible. • *Consistency*: Analysts can approximate the scaler via the venture's share of value captured from users and customers. Because this share expresses the relationship between value creation and revenues, the share needs to be adjusted for the ratio of revenue and total assets. • Initial share of value captured from customer and users / Estimated initial rate of revenue generation * Initial total assets • The initial share of value captured can be calculated using the bargaining power equations (e.g. Equation 4-22) and the fraction of paying customer and premium users (Table C-3). The initial product strength is one, the initial strength and number of competitors are estimated by the analyst (Table C-4). • The analyst can use different data points to estimate the initial rate of revenue generation. For example, some digital ventures report customer/user numbers and expected annual revenue per customer or user. These can be multiplied to determine the expected initial rate.

	Some SaaS companies also publish annualised recurring revenue rates, which can be used for this rate. Suppose the venture provides no such data point. In that case, the analyst should use the reporting revenue for the financial year ending at the beginning of the simulation as the best available estimate.

C.4. Fixed variables

The model assumes that some variables can be held constant across all companies. These fixed variables are outlined below with their values and explanation for the values (Table C-51).

Table C-15: Overview of fixed variables

Input	Value	Reasoning
Initial technological quality	1	• To index the initial product strength, use value creation, and rate of value creation. The technological quality is always set at 1. • Other initial value drivers are zero or one, depending on the venture's business model. However, all digital ventures require a digital technology.
Reporting period	1	• The model is validated using company annual reports. Therefore, the model sets the reporting period to one year.
Reporting delay	0.25	• The reporting delay reflects company typical quarterly reporting intervals to, for example, shareholders. • A value of one quarter also allows expectation formation to be reasonably quick without being too sensitive to short-term fluctuations.
Delay to lay off	0.1	• Reflects the time required to lay employees off. It is set to about 5.2 weeks (1/10 of a year) which is realistic considering managerial decision making and potential contract/legal delays to lay off.
Target managerial slack	0.5	• The target managerial slack has been set to 0.5. It means that the management has one-third of its time available to plan and execute growth plans (when operating at required staffing levels).
Effect of competence on ability to hire	12	• With the effects set at 12, a fully capable manager with no other tasks requires one month to fulfil hiring, complementary asset acquisition, and fundraising targets.
Effect of competence on ability to acquire CA		
Effect of competence on ability to raise capital		

Appendix D: Additional company inputs

Chapter 5 of the thesis has outlined the main inputs for each case company. However, besides those inputs noted in the Chapter, some minor additional inputs are required to run the model for each case company. They relate to goals regarding premium users and content creation. These inputs are zero for all companies because they do not employ freemium or content-based business models. While they are not required and relevant for any case company, they were implemented in the model to reflect the literature on digital ventures. Stocks' initial values and accounting measures also need to be set for each company separately.

D.1. Additional inputs for all companies

Chapter 5 of this thesis has outlined the managerial targets and limits for all companies (e.g. Table 5-1). In addition, analysts must set targets for the companies' premium user and content library growth (Table D-1). These are zero for the case companies because they do not distinguish between users and premium users. Nor do they employ a content-based business model. These need to be set to zero even though they are not relevant. Otherwise, the Vensim software creates an error as it expects some value for them.

Table D-1: Additional dominant logic inputs for all companies

Dominant logic – targets and HR	
Target premium user growth	0%
Target content library growth	0%
liquidity goal per content item	0%

In addition, each companies' content creation subsystem requires inputs (Table D-2). These inputs have been set to zero as the subsystem is not relevant for any identified company. The subsystem was built using structures verified and validated in other parts of the thesis (see Appendix A). This thesis has thus developed a model that reflects the theory on digital ventures wholistically. The model thus applies to any digital venture. However, the model has not been validated for content-based business models. Therefore, users should use it with caution for any company employing such a business model design.

Table D-2: Content creation subsystem inputs for all companies

Content creation inputs			
Rate of content creation per customer	0	Cost per internally created content item	0
Rate of content creation per user	0	Cost per acquired content item	0
Rate of content creation per premium user	0	Quality of acquired content	0
Effect of experience on customer content quality	0	Effect of experience on user content quality	0
Effect of competence on ability to create content	0	Effect of competence on content quality	0
Content lifetime	0	Acquisition of content	0

D.2. Additional inputs for Alpha

In addition to the inputs presented in Chapter 5, the model requires some additional inputs regarding initial values and accounting measures (Table D-3). All employee stocks are initialised with a value of one. Alpha does not employ any value delivering employees at the beginning of the simulation. Thus, this stock has an initial value of zero. Their value after one year of simulation is the reference point to index value delivering employees. Alpha does not have a content library because it does not employ a content-based business model. Its initial balance sheet resources are split into about 55% of financial resources, 5% of complementary assets, and 29% of technological resources. These are financed using no debt but ten times the value of its initial assets in equity. This number is high because the company went public via a reverse takeover where it bought a publicly traded, bankrupt company. This equity position includes the equity of the previous company.

Table D-3: Initial values and accounting measures for Alpha

Initial values for employee and balance sheet stocks			
Technology developing employees	1	Financial resources	55.21%
Marketing and selling employees	1	Complementary assets	5.23%
Value delivering employees	0	Technological resources	28.73%
Firm managing employees	1	Content assets	0.00%
Content library	0	Equity employed	1054.31%
		Debt employed	0.00%

Accounting measures	**t0**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**
Lifetime of comp. assets		3.222	2.764	2.664	1.622	1.405	1.532
Lifetime of tech. resources		4.07	3.09	2.22	1.52	2.72	6.05
Lifetime of content assets		0	0	0	0	0	0
Equity debt preference		100%	100%	100%	0.8%	100%	100%
Equity repurchasing		0%	0%	0%	0%	0%	0%
Debt repayment		0%	0%	0%	0%	200%	0%
Other assets	11%	12%	22%	29%	38%	47%	58%
Rolling annual taxation	0%	-3%	-5%	-17%	-15%	-12%	-13%

The table also provides the lifetimes of Alpha's resources in each year. Its resources have lifetimes between 1.4 and 6.05 years. Alpha raises only equity in all but the fourth year of simulation. It repays the debt in year five. Other assets included on Alpha's balance sheet and the venture's taxation (both indexed by initial total assets) are also imported to the model on an annual basis. At the beginning of the simulation, assets unaccounted for in the model make up 11% of Alpha's initial total assets. They rise over six years to 58%. Alpha receives tax credits of between 0% and 17% of the initial total assets per year.

D.3. Additional inputs for Beta

Beta employs staff across the four activities considered in the model at the beginning of the simulation. Therefore, all employee stocks have an initial value of 1 (Table D-4). Beta's initial balance sheet assets are composed of about 35% financial resources, 8% complementary assets, and 6% technological resources. The venture has raised 118% of initial total assets in equity, and another 3% in debt before the simulation starts. Beta does not employ a content-based business model. Therefore, it does not have a content library or content assets. Their initial values thus are zero.

Table D-4: Initial values and accounting measures for Beta

Initial values for employee and balance sheet stocks			
Technology developing employees	1	Financial resources	35.24%
Marketing and selling employees	1	Complementary assets	8.49%
Value delivering employees	1	Technological resources	5.56%
Firm managing employees	1	Content assets	0.00%
Content library	0	Equity employed	118.45%
		Debt employed	2.76%

Accounting measures	**t0**	**t1**	**t2**	**t3**
Lifetime of comp. assets		1.84	1.77	1.77
Lifetime of tech. resources		4.13	2.35	1.51
Lifetime of content assets		0	0	0
Equity debt preference		100%	100%	100%
Equity repurchasing		0%	0%	0%
Debt repayment		38.42%	54.73%	91.46%
Other assets	51%	52%	53%	46%
Rolling annual taxation	-0.37%	0.41%	0.45%	0.44%

The lifetime of Beta’s complementary assets stays nearly constant at a level of about 1.8 years throughout the simulation. The lifetime of its technological assets falls from 4.13 to 1.51 years over the three years of simulation. The venture raises all its capital in equity but repays parts of its initial debt over the simulation years. Beta holds additional balance sheet assets of around 50% of initial total assets, which are not considered in the model. Beta receives a small tax credit in the year ending at the beginning of the simulation and pays small amounts of tax in each of the following years.

D.4. Additional inputs for Gamma

Because Gamma has employees across four activities, their initial indexed values are 1 (Table D-5). Its initial balance sheet resources include about 29% of initial total assets as financial resources. Moreover, Gamma holds about 3% of complementary assets and technological resources each. The venture has raised 88% of its initial total assets in equity and 0.1% in debt. Gamma does not employ a content library or hold content assets.

Table D-5: Initial values and accounting measures for Gamma

Initial values for employee and balance sheet stocks			
Technology developing employees	1	Financial resources	29.32%
Marketing and selling employees	1	Complementary assets	2.98%
Value delivering employees	1	Technological resources	2.94%
Firm managing employees	1	Content assets	0.00%
Content library	0	Equity employed	87.85%
		Debt employed	0.10%

Accounting measures	**t0**	**t1**	**t2**	**t3**
Lifetime of comp. assets		3.12	3.13	2.79
Lifetime of tech. resources		2.69	1.50	1.33
Lifetime of content assets		0	0	0
Equity debt preference		94.2%	100.0%	94.6%
Equity repurchasing		0.00%	0.00%	4.52%
Debt repayment		119.30%	16.14%	0.56%
Other assets	65%	72%	81%	63%
Rolling annual taxation	0.46%	-0.15%	0.21%	-0.01%

Throughout the years, the lifetime of Gamma's complementary assets falls from 3.12 to 2.79 years. The lifetime of its technological resources falls from 2.69 to 1.33 years. Every year, the capital raised by Gamma is composed of at least 94% equity. The company repays significant fractions of debt in the first year of the simulation. Depending on the year, assets not considered in the model amount to between 63% and 81% of initial total assets. Gamma switches from receiving small amounts of tax credits to paying small tax charges every year.

D.5. Additional inputs for Delta

Delta's employee stocks have initial values of one to reflect that the venture employs staff across all four activities considered in the model (Table D-6). The assets considered in the model include about 23% of initial total assets in financial resources and less than 1% of initial total assets as complementary assets and technological resources. The venture has financed these assets using equity and debt of 83% and 4% respectively of initial total assets. Delta does not employ a content-based business model. It thus does not have a content library or content assets.

Table D-6: Initial values and accounting measures for Delta

Initial values for employee and balance sheet stocks			
Technology developing employees	1	Financial resources	22.57%
Marketing and selling employees	1	Complementary assets	0.74%
Value delivering employees	1	Technological resources	0.35%
Firm managing employees	1	Content assets	0.00%
Content library	0	Equity employed	82.81%
		Debt employed	3.83%

Accounting measures	**t0**	**t1**	**t2**	**t3**
Lifetime of comp. assets		1.40	1.56	2.72
Lifetime of tech. resources		1.26	2.02	1.21
Lifetime of content assets		0	0	0
Equity debt preference		100%	100%	100%
Equity repurchasing		0%	0%	0%
Debt repayment		150%	0%	45%
Other assets	76%	87%	91%	87%
Rolling annual taxation	0.66%	-0.47%	0.11%	2.08%

The lifetime of Delta's complementary assets rises from 1.4 to 2.7 years over the three simulation years. The lifetime of its technological assets fluctuated between 1.21 and 2.02 years. During its simulation, it raises its new capital entirely as equity. The company also repays significant amounts of debt in the first and third simulation years. Besides the assets recognised in the model, the company holds assets worth between 76% and 91% of its initial total assets. The company pays small amounts of taxes in all but the first year of simulation.

Appendix E: Overview of scenario inputs

Chapter 6 of this thesis has simulated the model for a range of hypothetical scenarios. These scenarios investigate and illustrate the performance development and trade-offs between value creation and capture for digital ventures. The chapter has outlined the principles guiding the design of the base case, its most essential inputs, and changes to the base case for additional scenarios. This appendix provides an overview of all model inputs required to run the base case. It presents inputs in the format used for case companies. It then illustrates changes to the base case for each scenario. Thereby, this appendix creates full transparency over the scenario simulations.

E.1. Base case model inputs

The base case with caps on employee numbers (BaseC) has the following inputs for its firm managing subsystem (Table E-1):

- The venture targets a customer growth goal and technology improvement goal of 25% and 10% per year.
- Its employee caps have been set at their initial indexed level of one. Thus, BaseC does not hire additional employees. The company operates at the maximum number of employees it is willing to hire.
- BaseC employs a SaaS business model. Thus, it does not distinguish between customers, users, and premium users. It also does not employ a content library. Therefore, all targets regarding users, premium users, and content are irrelevant for BaseC and set to zero.
- BaseC's initial capability level has been set to 0.5. This midpoint allows the venture to improve its employee productivity over time. It takes the venture one year to train its employees. This value is realistic compared to the case companies in Chapter 5 and allows the venture to improve capabilities within the five-year simulation period. New employees have a capability of 0.3 because they require integration into the venture's processes.
- The higher employee turnover rate of 30% has been set for BaseC.

- The venture does not raise any capital to acquire customers or users, improve its technology, or create content. Thus, the financial resources accumulate based on the venture's value creation and capture. Therefore, they can be used as a cumulative performance measure.
- The venture requires 7.5% of initial total assets per employee. The value has been set to ensure that the venture has initial complementary assets that are sufficient to equip its initial employees. Therefore, no acquisition of complementary assets and cash outflow takes place at the beginning of the simulation to correct imbalances.
- Similarly, BaseC's effect of competence on its ability to manage the firm has been set to 9. Thereby, the venture's initial firm managing employees can manage its operating employees with 50% managerial slack. Thus, no initial hiring or layoffs eliminate imbalances between required and employed firm managing employees.

Table E-1: Firm management inputs for the base case

Dominant logic – targets and HR		**time: 0 - 5**	
Target customer growth		25%	
Target user growth		0%	
Target premium user growth		0%	
Target technology improvement		10%	
Target content library growth		0%	
Marketing and selling (MS) employee cap		1	
Value delivering (VD) employee cap		1	
Tech. developing (TD) employee cap		1	
Firm managing (FM) employee cap		1	
Capabilities - firm managing		**Capital asset requirements**	
initial firm managing competence	0.5	complementary assets per emp.	7.5%
firm managing years of improvement	1	liquidity goal per customer	0
new FM employee competence	0.3	liquidity goal per user	0
Employee turnover rate	30%	liquidity goal per tech improvm.	0
effect of competence on ability to manage the firm	9	liquidity goal per content item	0

BaseC's technology developing capability settings are the same values as its firm managing capabilities (Table E-2). These allow the venture to improve its productivity over time. Each indexed employee at fully developed capabilities can maintain four times the venture's initial technological quality and develop 40% of initial total assets in new technological resources. These values ensure that the venture's initial technology developing employees can achieve its technology improvement goal of 10% (see Table E-1).

Table E-2: Technology developing inputs for the base case

Capability development			
initial technology developing competence	0.5	effect of competence on ability to develop technology	40%
TD years of improvement	1	effect of competence on ability to maintain technology	400%
new TD employee competence	0.3		

BaseC does not distinguish between customers, users, and premium users. Therefore, it employs only the model's customer stock, and its initial value is one (Table E-3). Variables related to users and premium users are zero. Moreover, the venture's word-of-mouth variables have been set to zero. They are altered as part of the environmental scenarios. The standard customer lifetime is five years. It reflects a mid-point of the values observed for case companies. Marketing and value delivering capabilities have the same values as the firm managing and technology developing capabilities (see Table E-1 and E-2). These allow for productivity improvements over time. Each indexed marketing and selling employee can acquire 1.5 indexed customers per year. Each indexed value delivering employee of BaseC can service two indexed customers. These effect sizes ensure that the venture is operating at full capacity at the beginning of the simulation. There is no idle capacity causing layoffs of employees or a capacity shortage requiring additional employees. Moreover, the venture's marketing and selling employees can initially achieve the venture's customer growth goal. This further prevents initial hiring and layoffs and ensures that all changes in performance outcomes are due to theoretically relevant internal changes.

Table E-3: Customer and user subsystem inputs for the base case

User and customer behaviour			
initial customer base	1	rate of customer acquisition per customer	0
initial user base	0	rate of customer acquisition per user	0
initial premium user base	0	rate of user acquisition per customer	0
user to premium conversion rate	0	rate of user acquisition per user	0
premium to user conversion rate	0	rate of premium user acquisition per cust.	0
standard customer lifetime	5	rate of premium user acquisition per user	0
standard user lifetime	0		
Capability development			
initial marketing selling competence	0.5	initial value delivering competence	0.5
MD years of improvement	1	VD years of improvement	1
new MS employee competence	0.3	new VD employee competence	0.3
effect of competence on ability to acquire customers			1.5
effect of competence on ability to acquire users			0
effect of competence on ability to acquire premium users			0
effect of competence on ability to service customers			2
effect of competence on ability to service users			0

As a SaaS company, BaseC does not utilise network effects (Table E-4). Because the venture does not distinguish between users and premium users, the premium product advantage and initial user usage intensity are zero. The same applies to other variables regarding user usage intensity. The maximum technological quality of BetaC and standard effect of investment has been set to 1.5. They align with the venture's technology developing capabilities in preventing immediate hiring and layoff. Moreover, the maximum quality allows the venture to improve the value it creates over time. Customer usage intensity variables also incorporate this potential for improvements in value creation. The maximum usage intensity of 1.5 allows the venture to increase its value creation.

Table E-4: Value creation inputs for the base case

Business model designs			
Customer direct network effect settings	0	Premium product advantage	0
Customer indirect network effect settings	0	Maximum technological quality	1.5
User direct network effect settings	0	Standard effect of investment in technology on tech. improvement	1.5
Customer indirect network effect settings	0		
Initial customer usage intensity	1	Initial user usage intensity	0
User and customer behaviour	**time: 0 - 5**		
Maximum customer usage intensity	1		
New customer usage intensity	1.5		
Standard rate of adoption by customers	0.5		
Maximum user usage intensity	0		
New usage intensity	0		
Standard rate of adoption by users	0		
Complementary product	**time: 0 - 5**		
Quality of complementary products	1		

A contract period of one year has been set (Table E-5). This length is similar to the value observed in case companies. BaseC loses value initially. The input values achieve this through costs of 25% of initial value creation. The value created is the maximum value that can be captured. At best, the venture thus breaks even with these costs. However, the venture operates in an oligopolist (0.5) with equally strong competitors (1). This combination reduced the share of value capture from customers. These values ensure that BaseC does not have an initial ability to capture value. The venture does not compensate providers of equity and debt.

Table E-5: Value capture inputs for the base case

Business model designs			
Customer contract period	1	Premium user contract period	0
Input providers		**time: 0 - 5**	
Cost of value delivering inputs		25%	
Cost of marketing and selling inputs		25%	
Cost of technology developing inputs		25%	
Cost of firm managing inputs		25%	
Cost of equity		0%	
Cost of debt		0%	
Competition		**time: 0 - 5**	
Number of competitors		0.5	
Strength of competitors		1	

The venture does not employ a content-based business model. Therefore, all inputs regarding the content creation subsystem are zero (Table E-6).

Table E-6: Content creation subsystem inputs for the base case

Content creation inputs			
Rate of content creation per customer	0	Cost per internally created content item	0
Rate of content creation per user	0	Cost per acquired content item	0
Rate of content creation per premium user	0	Quality of acquired content	0
Effect of experience on customer content quality	0	Effect of experience on user content quality	0
Effect of competence on ability to create content	0	Effect of competence on content quality	0
Content lifetime	0	Acquisition of content	0

BaseC is assumed to employ staff across all activities (Table E-7). Therefore, the venture's initial employee stocks have a value of one. Its initial financial resources are 100% of initial total assets. Its initial complementary assets and technological resources are 30% and 20% of initial total assets. These values are unrealistic because initial total assets amount to more than 100%. However, the initial value of financial resources at one allows an easy performance comparison. For example, a scenario that achieves financial resources of two has doubled its initial resources. The venture has financed these assets entirely by equity. Complementary assets and technological resources have a lifetime of three years. The value is with the range of lifetimes observed among case companies. BaseC does not repay any debt or equity. If it were to raise capital, it would do so entirely in equity. However, the model requires an input for the variable between zero and one. No other assets or taxation are imported to the model for BaseC. These are not theoretically relevant. The model used them to ensure consistency between accounting measures and model variables for testing purposes.

Table E-7: Initial values and accounting measures for the base case

Initial values for employee and balance sheet stocks			
Technology developing employees	1	Financial resources	100%
Marketing and selling employees	1	Complementary assets	30%
Value delivering employees	1	Technological resources	20%
Firm managing employees	1	Content assets	0%
Content library	0	Equity employed	150%
		Debt employed	0%

Accounting measures	t0	t1	t2	t3	t4	t5
Lifetime of comp. assets		3				
Lifetime of tech. resources		3				
Lifetime of content assets		0				
Equity debt preference		1				
Equity repurchasing		0%				
Debt repayment		0%				
Other assets	0%					
Rolling annual taxation	0%					

The sections below outline the changes made to the above base case inputs for individual scenarios. The tables outline only the changes to the base case to avoid repetition. The sections mirror Chapter 6's structure to allow the reader to easily compare this appendix's model inputs and the chapter's scenario outcomes.

E.2. Dominant logics with a cap on employee numbers

This section outlines the changes made to BaseC to simulate additional scenarios for companies with a cap on employee numbers. These scenarios change the targets expressed in the management's dominant logic and variables related to capability development to reflect internal improvements.

E.2.1. Different targets expressed in the dominant logic

Section 6.1.2 simulates different targets expressed in the management's dominant logic for companies with a cap on employee numbers. Three scenarios alter BaseC. These scenarios increase the venture's technology improvement target (TechC), its customer growth target (ScaleC), or both targets (AmbitiousC). The variable values are doubled to reflect higher targets (Table E-8).

Table E-8: Changes to employee-capped base case's dominant logic

Variables	BaseC	TechC	ScaleC	AmbitiousC
Target customer growth	25%	25%	50%	50%
Target technology improvement	10%	20%	10%	20%

E.2.2. Internal improvement for capability development

Section 6.1.3 alters variables affecting capability development to represent internal improvement programs (Table E-9). These maintain all but one input of BaseC. One scenario reduces the capability improvement times to half a year (TrainingC). Another scenario decreased new employee capabilities from 0.3 in BaseC to 0.1 (NewEmpsC). The last scenario in this section reduces the employee turnover rate from 30% to 10% (TurnoverC).

Table E-9: Changes to employee-capped base case's capability development

Variables	BaseC	TrainingC	NewEmpsC	TurnoverC
Capability improvement times	1	0.5	1	
New employee capability level	0.3		0.1	0.3
Employee turnover rate	30%			10%

E.3. Dominant logics without a cap on employee numbers

The second section of Chapter 6 simulates the development of companies without a cap on employee numbers. It outlines the development of a new base case without a cap on employee numbers (BaseU). It then investigates the impact of different managerial targets and internal improvements on BaseU.

E.3.1. Employee-uncapped base case

BaseU maintains all inputs from BaseC except its employee caps (Table E-10). BaseC is unwilling to hire more than its initial employee of one indexed employee per activity. BaseU does not have employee caps. These are reflected by a -1 in the model. The development of BaseU compared to BaseC is outlined in section 6.2.1.

Table E-10: Changes to develop BaseU

Dominant logic – targets and HR	BaseC	BaseU
Marketing and selling (MS) employee cap	1	-1
Value delivering (VD) employee cap	1	-1
Tech. developing (TD) employee cap	1	-1
Firm managing (FM) employee cap	1	-1

E.3.2. Different targets expressed in the dominant logic

Section 6.2.2 simulates the impact of different managerial targets on companies without a cap on employee numbers. These scenarios build on BaseU and maintain no cap on employee numbers. The scenarios implement the same changes used for BaseC's different targets (Table E-11).

Table E-11: Changes to employee-uncapped base case's dominant logic

Variables	BaseU	TechU	ScaleU	AmbitiousU
Target customer growth	25%	25%	50%	50%
Target technology improvement	10%	20%	10%	20%

E.3.3. Internal improvement for capability development

Section 6.2.3 changes variables related to capability development to simulate the impact of internal improvements on companies without a cap on employee numbers. These scenarios build on BaseU and do not have a cap on employee numbers. They apply the same changes used to simulate internal improvement for BaseC (Table E-12).

Table E-12: Changes to employee-uncapped base case's capability development

<table>
<tr><th>Variables</th><th>BaseU</th><th>TrainingU</th><th>NewEmpsU</th><th>TurnoverU</th></tr>
<tr><td>Capability improvement times</td><td>1</td><td>0.5</td><td colspan="2">1</td></tr>
<tr><td>New employee capability level</td><td colspan="2">0.3</td><td>0.1</td><td>0.3</td></tr>
<tr><td>Employee turnover rate</td><td colspan="3">30%</td><td>10%</td></tr>
</table>

E.4. Transitioning between dominant logics

The third section of Chapter 6 investigates the transition from dominant logics without a cap on employee numbers to logics with caps on employee numbers.

The section first describes a first transitioning base case. The section then explores different targets, layoffs, growth cycles, and internal improvements.

E.4.1. Transitioning base case

The transitioning base case (BaseT) in subsection 6.3.1 continues the development of BaseU for another five years. During the first five years, the settings are the same as for BaseU. Another five years of simulation are then added to BaseU to investigate the introduction of employee caps halfway through the simulation. Therefore, the venture has two growth states, similar to the case companies illustrated during model testing. During the first five years, the venture grows without a cap on employee numbers (Table E-13). During the second five years, it introduces caps on all employee numbers. These caps have been set by running the model without caps at first. Each activity’s cap is the respective employee number after five years of simulation.

Table E-13: Changes to develop BaseT

Dominant logic – targets and HR	time: 0 – 5 (=BaseU)	time: 5 – 10
Marketing and selling (MS) employee cap	-1	2.15
Value delivering (VD) employee cap	-1	2.9
Tech. developing (TD) employee cap	-1	0.7
Firm managing (FM) employee cap	-1	1.5

E.4.2. Different targets expressed in the dominant logic

The scenarios for employee-capped and -uncapped companies have investigated the impact of different targets. Transitions increase the possibilities and complexities of the dominant logic. Besides different targets, the simulations below also outline the development of companies with different restructuring sizes and growth cycles.

E.4.2.1. Different targets throughout the simulation

The first set of dominant logic-related scenarios investigates the development of transitioning companies with different growth and improvement targets. The scenarios use the same targets as for BaseC and BaseU (Table E-14). Subsubsection 6.3.2.1 shows the outcomes of these scenarios.

Table E-14: Changes to transitioning base case's dominant logic's targets (1)

Variables	BaseT	TechT	ScaleT	AmbitiousT
Target customer growth	25%	25%	50%	50%
Target technology improvement	10%	20%	10%	20%

The principles of the design of BaseT have been applied to these scenarios. The companies grow without caps on employee numbers during the first five years. Thus, their inputs for the first growth state are the same as for BaseU. During the second growth state, employee caps have been introduced. The employee cap for each activity reflects the number of employees employed by the venture at the end of the first growth state. Each scenario employs different numbers of employees to achieve its targets. Therefore, their employee caps differ (Table E-15).

Table E-15: Changes to transitioning base case's dominant logic's targets (2)

TechT	time: 0 – 5 (=BaseU)	time: 5 – 10
Marketing and selling (MS) employee cap	-1	2.15
Value delivering (VD) employee cap	-1	2.9
Tech. developing (TD) employee cap	-1	0.96
Firm managing (FM) employee cap	-1	1.5
ScaleT	**time: 0 – 5 (=BaseU)**	**time: 5 – 10**
Marketing and selling (MS) employee cap	-1	9.94
Value delivering (VD) employee cap	-1	10.6
Tech. developing (TD) employee cap	-1	0.65
Firm managing (FM) employee cap	-1	5.9
AmbitiousT	**time: 0 – 5 (=BaseU)**	**time: 5 – 10**
Marketing and selling (MS) employee cap	-1	9.9
Value delivering (VD) employee cap	-1	10.75
Tech. developing (TD) employee cap	-1	0.9
Firm managing (FM) employee cap	-1	6

E.4.2.2. Different restructuring magnitudes

BaseT sets the caps of employee numbers during the second growth state at the number of employees employed at the end of the first growth state. However, model validation has revealed that all companies reduce their employee numbers as part of restructuring programs. Therefore, the impact of layoffs should also be evaluated. Subsubsection 6.3.2.2. illustrates two scenarios. They are based on and adapt BaseT. During the first five years, they grow without employee limits. During the second half of the simulation, they introduce caps on employee numbers. However, the caps of employee numbers are 20% and 50% below those in BaseT (Table E-16). Therefore, the companies lay off 20% and 50% of employees when transitioning between growth states.

Table E-16: Changes to transitioning base case's dominant logic's restructuring

Reductions20	**time: 0 – 5 (=BaseU)**	**time: 5 – 10**
Marketing and selling (MS) employee cap	-1	1.72
Value delivering (VD) employee cap	-1	2.32
Tech. developing (TD) employee cap	-1	0.56
Firm managing (FM) employee cap	-1	1.2
Reductions50	**time: 0 – 5 (=BaseU)**	**time: 5 – 10**
Marketing and selling (MS) employee cap	-1	1.075
Value delivering (VD) employee cap	-1	1.45
Tech. developing (TD) employee cap	-1	0.35
Firm managing (FM) employee cap	-1	0.75

E.4.2.3. Different number of growth cycles

BaseT involves one growth cycle with an initial period of growth followed by an employee-capped period. However, companies may switch more regularly between dominant logics. Therefore, subsection 6.3.2.3 created scenarios with two and five growth cycles. These build on and follow the same principles as BaseT. After an initial period of growth, the scenarios introduce caps on employee numbers. These caps are set to the employee numbers at the end of the previous growth period (Table E-17).

Table E-17: Changes to transitioning base case's dominant logic's growth cycles

<table>
<tr><th>2Cycles</th><th colspan="2">time: 0 – 2.5</th><th colspan="2">time: 2.5 – 5</th><th colspan="2">time: 5 – 7.5</th><th colspan="2">time: 7.5 – 10</th></tr>
<tr><td>MS employee cap</td><td colspan="2">-1</td><td colspan="2">1.3</td><td colspan="2">-1</td><td colspan="2">3.1</td></tr>
<tr><td>VD employee cap</td><td colspan="2">-1</td><td colspan="2">1.8</td><td colspan="2">-1</td><td colspan="2">4.4</td></tr>
<tr><td>TD employee cap</td><td colspan="2">-1</td><td colspan="2">0.75</td><td colspan="2">-1</td><td colspan="2">0.7</td></tr>
<tr><td>FM employee cap</td><td colspan="2">-1</td><td colspan="2">1</td><td colspan="2">-1</td><td colspan="2">2.2</td></tr>
<tr><th>5Cycles</th><th>0-1</th><th>1-2</th><th>2-3</th><th>3-4</th><th>4-5</th><th>5-6</th><th>6-7</th><th>7-8</th><th>8-9</th><th>9-10</th></tr>
<tr><td>MS employee cap</td><td>-1</td><td>1.1</td><td>-1</td><td>1.4</td><td>-1</td><td>1.97</td><td>-1</td><td>2.9</td><td>-1</td><td>4.4</td></tr>
<tr><td>VD employee cap</td><td>-1</td><td>1.4</td><td>-1</td><td>1.8</td><td>-1</td><td>2.55</td><td>-1</td><td>3.9</td><td>-1</td><td>6</td></tr>
<tr><td>TD employee cap</td><td>-1</td><td>0.93</td><td>-1</td><td>0.75</td><td>-1</td><td>0.7</td><td>-1</td><td>0.7</td><td>-1</td><td>0.7</td></tr>
<tr><td>FM employee cap</td><td>-1</td><td>1.1</td><td>-1</td><td>1</td><td>-1</td><td>1.3</td><td>-1</td><td>1.9</td><td>-1</td><td>2.9</td></tr>
</table>

E.4.3. Internal improvement for capability development

Subsection 6.3.3 simulates the impact of internal improvements on transitioning companies. These adapt BaseT by changing the capability development variables in the same manner as for BaseC and BaseU (Table E-18).

Table E-18: Changes to transitioning base case's capability development (1)

Variables	BaseT	TrainingT	NewEmpsT	TurnoverT
Capability improvement times	1	0.5	1	
New employee capability level	0.3		0.1	0.3
Employee turnover rate	30%			10%

During the first growth state, the scenarios grow without caps on employee numbers. They follow the same development as BaseU. The ventures then introduce employee caps for the second half of the simulation. These caps are the number of employees at the end of the first growth state. Like the simulations for different targets, each internal improvement scenario may set a different employee cap. Therefore, these values must be set individually for each scenario (Table E-19).

Table E-19: Changes to transitioning base case's capability development (1)

TrainingT	time: 0 – 5 (=BaseU)	time: 5 – 10
Marketing and selling (MS) employee cap	-1	2.5
Value delivering (VD) employee cap	-1	3.17
Tech. developing (TD) employee cap	-1	0.76
Firm managing (FM) employee cap	-1	1.74
NewEmpsT	**time: 0 – 5 (=BaseU)**	**time: 5 – 10**
Marketing and selling (MS) employee cap	-1	1.84
Value delivering (VD) employee cap	-1	2.49
Tech. developing (TD) employee cap	-1	0.63
Firm managing (FM) employee cap	-1	1.08
TurnoverT	**time: 0 – 5 (=BaseU)**	**time: 5 – 10**
Marketing and selling (MS) employee cap	-1	1.93
Value delivering (VD) employee cap	-1	2.52
Tech. developing (TD) employee cap	-1	0.62
Firm managing (FM) employee cap	-1	1.15

E.5. Contextual influences and robustness

The chapter also confirms the findings of the above scenario outcomes across different environments and business models. Section 4 of the scenario simulation chapter illustrates this contextual robustness.

E.5.1. Different environmental conditions

Chapter 6 confirms the findings of employee-capped and -uncapped companies across different stable and dynamically changing environments.

E.5.1.1. Stable environments

Subsubsection 6.4.1.1 confirms the development patterns observed for employee-capped and -uncapped simulations. It simulates a favourable environment with improved customer usage intensities, lifetimes, word-of-mouth marketing, and complementary quality (Table E-20). It also simulates a hostile environment with higher input costs, more competition, and stronger competitors. These simulations are run for BaseC and BaseU to evaluate the robustness of findings for both types of dominant logic.

Table E-20: Changes to reflect differently attractive stable environments

<table>
<tr><th>Variables</th><th>Hostile</th><th>Base</th><th>Favourable</th></tr>
<tr><td>Maximum customer usage intensity</td><td colspan="2">1.5</td><td>2</td></tr>
<tr><td>Standard rate of adoption</td><td colspan="2">1</td><td>2</td></tr>
<tr><td>Standard customer lifetime</td><td colspan="2">5</td><td>8</td></tr>
<tr><td>Rate of customer acquisition per customer</td><td colspan="2">0%</td><td>10%</td></tr>
<tr><td>Quality of complementary products</td><td colspan="2">1</td><td>2</td></tr>
<tr><td>Costs of each type of input</td><td>30%</td><td colspan="2">25%</td></tr>
<tr><td>Strength of competitors and substitutes</td><td>1.5</td><td colspan="2">1</td></tr>
<tr><td>Number of competitors and substitutes</td><td>1</td><td colspan="2">0.5</td></tr>
</table>

E.5.1.2. Dynamics environments

Subsubsection 6.4.1.2 evaluates the robustness of findings in dynamically changing environments. It simulates an improving and a worsening environment (Table E-21). These environments change from their base case values to favourable and hostile values over five years. These simulations are run for BaseC and BaseU to evaluate the robustness of findings for both types of dominant logic.

Table E-21: Changes to reflect different environmental dynamics [33]

Variables	Hostile	Base	Favourable
Maximum customer usage intensity	1.5		1.5 -> 2
Standard rate of adoption	1		1 -> 2
Standard customer lifetime	5		5 -> 8
Rate of customer acquisition per customer	0%		0 -> 10%
Quality of complementary products	1		1 -> 2
Costs of each type of input	25% -> 30%	25%	
Strength of competitors and substitutes	1 -> 1.5	1	
Number of competitors and substitutes	0.5 -> 1	0.5	

E.5.2. Different business model designs

The fourth section of Chapter 6 also evaluates the robustness of findings regarding different business model designs and activity effect sizes.

E.5.2.1. Business models with network effects

Subsubsection 6.4.2.1 outlines the business models of a social network and marketplace. These distinguish between customers and users, have different sets of network effects, target user growth, and have effect sizes for user acquisition and servicing (Table E-22). These settings have been applied to BaseC and BaseU to confirm their development patterns for different business model designs.

Table E-22: Changes to reflect business model with different network effects

Variables	Base	Network	Marketplace
Initial customer base	1	0.5	0.5
Initial user base	0	0.5	0.5
Target user growth rate	0	25%	25%
Customer direct network effect settings	0	-1	-1
Customer indirect network effect settings	0	1	1
User direct network effect settings	0	1	-1
User indirect network effect settings	0	0	1
effect of competence on ability to acquire users	0	1.5	1.5
effect of competence on ability to service users	0	2	2

[33] For improving and worsening conditions, the left and right values reflect, respectively, the value at the beginning and end of the simulation. For example, the term "5 -> 8" for customer lifetime represents that the customer lifetime is five years at the beginning of the simulation. At the end of the simulation, it is eight years. During the five years of simulation, the model interpolates between these two values linearly. For example, after one year of simulation, the customer lifetime was 5.6 years.

E.5.2.2. Business models with different efficiency levels

Companies may also develop different activity systems. These are reflected in the effect sizes that transform capabilities to hard impacts on resource flows. Subsubsection 6.4.2.2 designs three scenarios with higher and lower effect sizes. These different effect sizes are evaluated for BaseC and BaseU.

Table E-23: Changes to reflect business model with different capability effect sizes

Variables	Lower50	Lower20	Base	Higher20
effect of competence on ability to develop technology	0.2	0.32	0.4	0.48
effect of competence on ability to maintain technology	2	3.2	4	4.80
effect of competence on ability to acquire customers	0.75	1.2	1.5	1.8
effect of competence on ability to service customers	1	1.6	2	2.4
effect of competence on ability to manage the firm	4.5	7.2	9	10.8