Inside the resource allocation process

An agent-based model design of the resource allocation process

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INSIDE THE RESOURCE ALLOCATION PROCESS

An agent-based model design of the resource allocation process

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ABSTRACT

The world is currently a rushed environment; things change faster than ever. Technological innovations impress us again every year. Many innovations that enhance society are the result of innovating organisations. These organisations invest in innovative solutions, for their own good, but eventually also for the greater good. Allocating resources to these investments is therefor an important aspect of innovation. This thesis has been conducted to gain more insights in the resource allocation process, the process which determines the investments executed in organisations. The resource allocation process model as defined by Bower and Gilbert helps managers and executives to create awareness about allocating their valuable, finite resources. Bower and Gilbert tried to create a simple model without a lot of predefined mechanisms, but their model lacks detail and therefore the inner mechanisms of each sub-process of the resource allocation process is a gap in the literature, there are some scholars who describe specific cases in detail, but there is no generic interpretation.

This research gap has been the foundation of this research and has led to the development of an agent-based model of the resource allocation process. Within the development of the simulation model all core processes had to be defined in detail. And since the objective is to develop a generic simulation model, the core of the sub-processes and inner mechanisms had to be defined. One of the most important mechanisms is the way an organisation can influence their own resource allocation process. This happens through structural and strategic context determination. With these two types of context determination, organisations can influence their allocation process in order to either execute more induced strategic action (action which corresponds with the defined corporate strategy) or more autonomous strategic action (action which lies outside the defined corporate strategy). Which type of strategic action is necessary depends on the specific situation of an organisation. With the knowledge of these two kinds of determination the sub-processes and their mechanisms had to be defined. Definition of these sub-processes happened through literature research. There are two topics within these processes: *Definition* and *Selection*. The basic principles of these two topics had to be known in order to be able to formulate a possible generic detailed definition of the sub-processes. This resulted in a conceptual model which, through formalisation could be implemented.

Before implementing an agent-based model the detailed definition had to be complete in order for the model to function. The implemented model has been tested on known phenomena derived from literature. The model is able to reproduce the expected strategic action under specific organisational context settings. Within a dynamic environment the model reproduces expectations for the contextual settings. And the mechanism of an increasing opportunity space can be reproduced. The model is unable to fully capture the effect of communication and divergence on the autonomous strategic actions. These results support concluding that the developed agent-based model is able to simulate the resource allocation process of a hypothetical organisation. With the model, the boundaries of the resource allocation process can be explored on proportion of control versus organisational learning. The model is also be able to analyse the effect of organisational changes on the strategic actions. Currently the model as implemented is unable to simulate a real-world case, but the potential for use within organisations and further research is certainly there.

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After such a long journey it is time to end something I really enjoyed but I am also really curious to my future steps!

Diederik de Planque

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

To innovate is a well-known term, it means making changes in something established by introducing new methods, ideas or products. The world needs innovation in order to overcome problems such as challenges within the fields of energy transition, changes in transportation or changes in data usage. In order to deal with these challenges both governmental and private institutions have to innovate. A lot of the important innovations come from commercial companies e.g. mobile phones facilitating communication and solar panels reducing dependence on fossil fuels. Innovations are necessary to keep the firms competitive; companies need to innovate in order to stay ahead of their competitors. When companies are complacent, and do not innovate, they will be out performed by their competition. Furthermore, innovation means improvement. For both cases changes can currently happen extremely fast, although organisations need to be careful with their innovations as they usually cannot afford to be wrong. In the most extreme case, competition could take over their market position. A less extreme example would be missing out on business opportunities or delaying innovative solutions. Therefore most organisations handle their investments with care and take well considered decisions while allocating their resources. Understanding the process of resource allocation could therefore help the organisations make better decisions while allocating their resources and would assist in the overall innovation rate.

The process which defines how financial, physical, technological and human resources are allocated within a firm or organisation is called the resource allocation process [Bower, 1970]. The allocation of the resources is required in order for the firms to be able to change or even operate and mismatching the allocation of resources can be very expensive. But a careful review of the research, reveals that the resource allocation process is more than just the allocation of resources. Resource allocation results in the realised strategy of the firm, the resource allocation process includes the way plans are defined and the manner in which resources are actually deployed [Bower and Gilbert, 2005]. Just like Bower and Gilbert, several scholars describe resource allocation as the essence of strategy [Bower, 1970; Mintzberg, 1978; Maritan and Lee, 2017; Noda and Bower, 1996; Sengul et al., 2019]. The resource allocation process translates the planned strategy into strategy execution, as the result of the resource allocation process are executed actions. A general model of this process as designed and updated by Bower and Gilbert [2005] is a helpful tool for large organisations to understand how to handle their resource allocation. In essence the resource allocation process is critical for organisational value creation. Unfortunately a significant weakness within the resource allocation process is that managers appear to make consistently inefficient capital allocation decisions as argued by Vieregger [2012] and Bower [2017]. According to Bower [2017] the core of the problem is the increasing complexity in the process. In order to properly manage the resource allocation process, knowledge and understanding across the levels and functional lines of the company is necessary [Bower, 2017].

Research on the resource allocation process has been conducted since around 1960 [Bower, 2017]. In 1970 Joseph L. Bower, one of the founding fathers of research on the resource allocation process, published his first book ”Managing the resource allocation process”. Several scholars and Bower himself refined his research published in 1970. Bower presented the ”Model of the resource allocation process” in his book of 1970 [Bower, 1970]. This model has been improved over the years and the most recent update of the model has been published in 2005 by Bower and Gilbert [2005]. While the resource allocation process has been researched for over 60 years almost all literature uses the same research methods. The resource allocation process is still strongly coupled to the financial model of capital budgeting which poorly fits the problem, as changing markets, global competition and technology have increased the complexity in the problem's firms are facing [Bower, 2017]. According to Bower [2017] the forces that must be taken into account are cognitive, organisational and interpersonal as well as economic. At the end of his personal reflection he states: "What we need badly are new concepts that illuminate how these basic activities influence resource allocation and how those relationships can be improved" - Bower [2017].

With the increasing complexity as addressed by Bower, it is time to use an alternative research method. Within complex phenomena it is interesting to know why something occurs, which follows the urge for illuminating concepts of Bower. Modelling is such a method which could serve to explain complex phenomena [Edmonds et al., 2019]. If a simulation is able to reproduce phenomena of a complex process, the simulation can be used to support the explanation of that process. In order to simulate the complex processes, they have to be made explicit and can thus support the explanation of the complex processes. Simulation would then make it possible to test conditions and cases which help understanding when the phenomena occur. Constructing a model of the resource allocation process can thus be a method to research how the basic activities and those relationships of Bower [2017] could be improved. Before starting research of how these relationships could be improved, a model would need to be constructed. Therefore this thesis will focus on the possibility of defining a model where if possible future research could focus on improvement of the relationships within the resource allocation process.

Within this chapter, the resource allocation process has been introduced as critical for organisational value creation. It helps organisations apply their valuable resources in a structured way. The outcome of organisational value creation helps the world to innovate and thus overcome the problems we face. The framework provided by Bower and Gilbert [2005] helps management to consider all aspects of resource allocation within their organisation, but the complexity of this process is increasing as one of the founding fathers addresses in [Bower, 2017]. Therefore this thesis will focus on delivering a basis for future research on resource allocation and the relationships within that process, as this will also result in more insight into the complexity. Future research can be based on the developed of a simulation model about the resource allocation process based on the revised model of Bower and Gilbert [2005].

2 DEFINING CORE CONCEPTS AND RESEARCH QUESTIONS

The chapter will start with definitions of the core concepts of resource allocation as defined in the resource allocation process model of Bower and Gilbert [2005]. After which, a further review of the resource allocation process literature is discussed. Followed by discussing the possibility of using agent-based modelling, which will result in a research objective. Finally, the chapter will conclude in a formal research question with complementary sub-questions.

2.1 INTRODUCTION TO RESOURCE ALLOCATION

Resource allocation is dividing financial, physical, technological and human resources between divisions of an organisation that all need resources. In general the resource allocation process is a matter of cost and availability of capital measured against the likely return. The focus in most capital budgeting systems is on quantitative summary ratios, such as return on investment, which is then used to decide which proposals will be funded [Bower, 2017]. Joseph L. Bower [1970] started his research in order to help organisations manage their resources more efficiently. He mapped the process and came up with a first version of the resource allocation process model. From that starting point there have been many scholars who researched the resource allocation process. Research over time has led to a revised model by Bower and Gilbert [2005] as presented in figure 2.1. This model is divided into three **management levels**, for each level there is a **definition** and **selection** process. The **internal context** is defined as the structural and strategic context, and finally the **external context** has been defined as the capital and product market context. This framework helps management structure their thought by which they could increase efficiency on the resource allocation and influence their preferred outcome. Next to an increase in efficient resource allocation the model indicates how organisations implement abstract long-term corporate goals [Schmidt and Rühli, 2002]

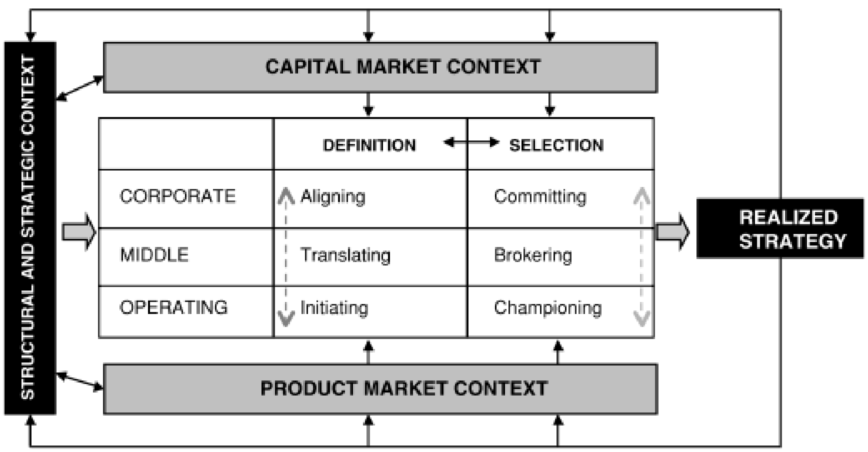

Figure 2.1: Revised model of resource allocation retrieved from Bower and Gilbert [2005]

Definition and selection

The definition and selection processes define the inner processes of the resource allocation process. When all these processes are executed the result is the actual allocation of resources and thus the executed strategy. The **definition** processes within an organisation are the processes in which each of the management levels defines their content. The **corporate management** aligns their corporate mission, financial goals and objectives and strategy with the performance of their organisation and vice versa [Bower and Gilbert, 2005]. The **middle management** translates the initiatives proposed by the **operating management** and integrates the corporate business thinking with the proposed initiative [Bower, 2005].

The **selection** processes define the way the initiatives get selected on each management level and determines where each level is going to commit on. The selection for the **operating management** level means that they decide which investment options fits best for the organisation. They promote their selected initiative to the middle management. The **middle management** in turn acts as a broker between the corporate and operating management, middle management filters the potentially successful initiatives before introducing them to corporate management. Eventually **corporate management** commits to several initiatives and resources can be allocated [Bower, 2005; Burgelman, 2002]. The allocation of resources results in the **realised strategy**, these inner processes thus define the route from a strategic plan to an executed strategy.

Internal context

The internal context is defined by the structural and strategic context. These contexts define how the definition and selection processes are executed. With the help of these context the organisation is able to influence the strategic actions of the organisation. The strategic actions is what the organisation actually does [Burgelman, 2002]. There are two types of strategic action; induced strategic action and autonomous strategic action. Induced strategic actions involves initiatives which are oriented to gaining and maintaining leadership in the companies core business, thus are in line with the corporate strategy. While autonomous strategic actions involve initiatives oriented outside the scope of the corporate strategy at the time they come about. Both types of strategic actions are simultaneously within an organisation as they are not sufficient for continuous adaptation by themselves [Burgelman, 2002].

The **structural context** was introduced by Bower [1970] within the resource allocation process. Burgelman [2002] defines the structural context as "Structural context encompasses organisational structure, planning and control systems, resource allocation rules, measurement and reward systems, among other administrative arrangements, as well as cultural aspects such as recruitment and socialisation processes and more or less explicit principles of behaviour". Bower [2005] defined the structural context as "the formal organisation, the way businesses are measured, and the way functional and general managers are measured and rewarded". Both scholars agree that the structural context defines a set of forces that influences the processes of definition and selection. In other words the structural context comprises the administrative and cultural mechanisms that corporate and middle management can use to maintain the link between strategic action and the existing corporate strategy. Thus the structural context defines the organisations organisational measures, rules and cultural habits. Furthermore, the structural context defines the ways firms reward their employees (e.g. the incentive structure). Changing an organisations structural context could be a top-down process [Burgelman, 1983]. When management changes the structural context, they are able to influence the type of proposals which will be defined and selected. With cash incentives management can increase short-term profitability and with the use of stock incentives they cause more long-term projects to be introduced [Souder and Shaver, 2010].

While the context can be influenced top-down, the context could also be influenced bottom-up. Convincing top management a initiative's value can change the structural context in such a way that you might receive the resources, time and space needed for the initiative to become successful [Burgelman, 2002], this process is referred to as championing.

Burgelman [1983] also introduced the **strategic context** within the resource allocation process. The strategic context allows the organisation to evaluate and select autonomous strategic actions, which happens through various interactions between the management levels. The key function is to link new business opportunities to the corporate strategy and thus embrace it [Burgelman, 2002]. Sull [2005] provided an example about disinvestment where he states that the strategic context refers to the organisations official strategy. In the case Sull describes the strategic context induces initiatives consistent with the strategy while discouraging autonomous strategic actions. Thus the strategic context defines if the organisation is allowed to take strategic actions outside the defined strategy.

External context

The external forces on the resource allocation process are defined by the **capital and product market context**. The capital and product market contexts have an impact on the organisation but the organisation is not able to influence them directly. Many scholars have discussed the external influences on the resource allocation process. Examples are, powerful capital providers, powerful customers, R&D projects of competing firms, performance of competing firms and the influence of the overall market. Sull [2005] argues that powerful customers could cause disinvestment within the allocated resources or even project termination (e.g. shut down of a plant or an R&D project). Asymmetry in payoff between investment and disinvestment proposals are influenced by the powerful customers as initiatives often do not meet the direct needs of the customers, therefore proposed initiatives fail to attract management support [Christensen and Bower, 1996; Sull, 2005; Bower, 1970]. Not only does disinvestment happen through not meeting the customers direct needs, but also when operational management fails to understand the definition of the importance of the planned strategy; it might then fail to initiate projects according to the planned strategy.

2.2 RESOURCE ALLOCATION LITERATURE REVIEW

Extensive research has been performed on the resource allocation process, and a lot of development has happened since Bower started his research in 1960. The literature mainly focuses on specific cases and the external influences on the allocation process. Investing in new businesses or technical innovations brings lots of uncertainties and increase the complexity of the resource allocation process. There are many reasons why not to invest in new technologies, there might be a financial reason or a lack of knowledge. Also, external influences on (R&D) projects play a significant role [Wry et al., 2013]. While it is very important to invest in innovative technologies, the importance of technological disruptive innovations have been underestimated by both academic scholars and industrial practitioners [Yu and Hang, 2011].

Sull [2005] looked into the top-down pressure of the resource allocation, according to him the allocation process gets influenced by pressure for disinvestment by banks or shareholders in situations of financial distress. But also through indirect pressure, by focusing on financial discipline (profitability over growth) resulting in a shift of focus to the structural context in the resource allocation process. Sull [2005] also found that consolidating the resource allocation process under the CEO creates vulnerabilities due to limited cognitive frame of an individual setting the strategic context. Hutchison-Krupat and Kavadias [2015] address a consequence asymmetry between the senior and project managers if an initiative fails. The organisation incurs full cost of the resources for the initiative, whereas the project manager faces organisational penalties, such as lack of promotions, lower status, or potentially even lowered bonuses or raises. Which could cause misalignment between the management layers.

Souder and Shaver [2010] describe that well performing organisations make more long horizon investments, although this relationship becomes less strong when firms age. Their explanation is that managers are influenced through bonuses and job security, they become overly concerned with short-term results, as they benefit more from short-term investments. Souder and Shaver [2010] argue that managers can be realigned with the organisations interests through long-term incentives such as stock options as bonuses, which is a structural decision. A reason to focus less on the long-term corporate goals is an increase in organisational penalties, the penalties may prompt the organisation to choose a narrower scope and affect the decision-making process by creating preference for approval of profitable initiatives [Hutchison-Krupat and Kavadias, 2015]. Hereby the firms are more likely to invest in core task projects and withhold innovative projects which could have large societal impact.

Hutchison-Krupat and Kavadias [2015] looked at the differences between top-down and bottom-up strategies in order to successfully allocate the resources to innovative projects. Their conclusion, there is no choosing between top-down and bottom-up strategies, because both may be necessary for specific types of investment. Vieregger [2012] suggest future research to explore theories of how managers can best leverage the capability to improve performance through strategic capital allocation. Maritan and Lee [2017] writes that the resource allocation problem is more complex than current models and tools of analysis used by researchers can accommodate. Sandström et al. [2014] argue that there is a need for managerial solutions. And in addition [Bower, 2017] argues in a personal reflection: ”over time, changes in the capital markets, in the flows of technology, and in the patterns of global competition have meant that the dilemmas facing company managements are far more complex than the models and concepts academic researchers use to describe them. Which may well be because the forces that must be taken into account are cognitive, organisational, and interpersonal as well as economic and thus cross the lines of academic disciplines, while the time horizon of these problems exceeds the scope of a typical academic research project. There is important research to be done”. This corresponds to earlier findings of the complexity of the process.

2.3 AGENT-BASED MODELLING

In the introduction, modelling has been introduced as an alternative research method. The literature was reviewed and there is no source which describes the resource allocation processes in detail. Bower's call for new concepts [Bower, 2017], that illuminate how the basic activities influence the resource allocation process, might be answered by agent-based modelling. Agent-based modelling is a research method where the effects of action and reaction are studied with the help of simulation. It uses agents, which are things that have a state, and interact with other agents in an environment [Shalizi, 2007]. The interacting agents operate according a given set of rules but serve to pursue a common goal. Constructing such models requires an understanding of the processes in detail. Unfortunately current literature does not address the required level of detail to define an agent-based model. That is where principles of generative science come forward, it makes use of microspecifications to generate the macrophenomena [Epstein, 2006]. In other words using smaller proven principles to merge into a model which is able to reproduce the phenomena. The generative science can therefore be used to fill in the gap of the relatively undefined processes of the resource allocation process.

Preceding current research, a basic agent-based simulation model has been developed of the resource allocation process by de Planque and aan het Rot [2020]. The preceding developed simulation model focused on the basic rules of the resource allocation process by Bower and Gilbert [2005] and simulated the effects of solvency on the allocation process. de Planque and aan het Rot [2020] recommended to further develop the simulation model with a greater level of detail. The detail of contexts has been very basic in their model and mainly focused on the effect of the outcome of a specific context. Next to further development of the context mechanisms, another recommendation was to introduce organisational learning principles within their model.

2.4 RESEARCH OBJECTIVE

The objective of this research is to develop an agent-based model to support further research on the resource allocation process. The model of Bower and Gilbert [2005] explains the phenomenon of the resource allocation process but does not provide full details required for an agent-based simulation model. Therefore the main requirement of this research is to define those details in a way that they can be used in an agent-based model that can then facilitate further research. The structural and strategic context seem to define the core of the behaviour of the resource allocation process as defined in chapter 2. Both contexts have been specified quite carefully according to Bower and Gilbert [2005]; Burgelman [2002] and many other scholars, but in order to be suitable for modelling the theory needs to be conceptualised. One of the conclusions of de Planque and aan het Rot [2020] was that the context needed further elaboration in the agent-based simulation model and more detail is required. The definition and selection process which plays a large role within the research allocation process would need to be specified into detail, as this would be the "working" mechanism of the research allocation process. Numerous researches focus on the external influences on the resource allocation process while almost none try to describe the inner processes. Therefore the external context will not play a large role within the design of an agent-based model as the goal is to design a model which helps with understanding of the causal relationships and complex processes.

2.5 RESEARCH QUESTIONS

To conclude, current literature is quite specific for several cases and agrees on the rising complexity of the allocation of the resources. While most literature used classical research methods they no not describe how the inner processes of the allocation process actually work. They mainly focus on specific parts of the allocation process or on specific case studies. With newer research methods that focus on the analysis of complex systems it would be useful to dive into the inner mechanisms of the resource allocation process as designed by Bower and Gilbert [2005]. With the help of the reviewed literature the resource allocation process can be defined as a complex adaptive system. The process has many different interactions between several actors, where they organise themselves within a specific environment and show a collective behaviour [Baumann, 2015]. Based on this and the preceding agent-based modelling research, this research will focus on creating an agent-based simulation model of the resource allocation process. The result of the research will be a functioning, general agent-based model of the resource allocation process, which will function as a basis for the research as proposed by Bower [2017]. The outcome of this research will provide a basis for future directions of research within the resource allocation process. When more insight in the complexity of the resource allocation process is created, future research might be able to expand the knowledge of the inner processes and how to influence the allocation process according to the strategy of the organisation. Therefore the following research question has been defined:

> *What generative theory formulates the resource allocation process from Bower and Gilbert in order to make it suitable for modelling?*

In order to answer the research question, the research will keep the model of Bower and Gilbert [2005] as the main model of the resource allocation process. With the definition of the core concepts of the resource allocation process model (figure 2.1) it became clear that the inner processes can be influenced from inside and outside an organisation. The internal context is defined by the **structural** and **strategic** context. A result of the literature review is that the internal context is important as it defines how the processes within the resource allocation process take place. Through the settings of the structural and strategic contexts the internal processes can be influenced. Therefore the first sub-question has been defined:

> *What mechanisms define the structural and strategic context of the resource allocation process in a way that they are suitable for conceptualisation?*

In order to construct a theory which can be modelled a conceptualisation is required. The conceptualisation defines what the model should do, what mechanisms it should show and which leavers can control the model. Therefore the second sub-question has been defined as:

> *What conceptualisation describes the resource allocation process suitable for model implementation?*

The last sub-question is aimed towards testing the constructed model on the theoretical phenomena. The model can support in explanation of the process if the simulation is able to match a (known) expected outcome. In this case the model should be able to reproduce theoretical phenomena in an expected setup. The following sub-question will clarify how well the model is able to simulate the phenomena with the constructed model:

> *Which theoretical phenomena can be simulated with the constructed theories?*

3 RESEARCH APPROACH

In the previous chapter the core concepts and research questions have been defined. The resource allocation process model as defined by Bower and Gilbert [2005] has been introduced as a well-designed model for resource allocation. This resulted in the research question with several sub-questions. This chapter will discuss the methods used within the research after which the research flow will be discussed.

3.1 RESEARCH METHODS

For this research the main objective is to develop an agent-based model in order to support explanation and understanding of the mechanisms in the resource allocation process. The main method to develop this model is a model-based approach. Before concluding that an agent-based model could be of use for research of the resource allocation process, a model has to be constructed. Methods supporting the development of the model are; literature research, desk research, discussions with an expert in the field, and data analytical methods.

3.1.1 Literature research

In order to understand the mechanisms of the resource allocation process, a literature research is conducted. The main literature has been about the resource allocation process, agent-based modelling, control systems and other relevant business literature. The literature used to support the desk research has been derived from several books and academic papers. The findings of the literature, especially from the resource allocation process, have been discussed with an expert in the field. The discussions with an expert in the field helped develop understanding of the concepts as these concepts are often quite vague.

The results of the literature research have functioned as input for the desk research. With the generative science theory in mind, as introduced in chapter 2, the desk research merged literature concepts into theories about functioning of specific mechanisms and processes. These theories have been continuously discussed with an expert and have continuously been adapted while modelling.

3.1.2 Model design

The agent-based paradigm has been used as main method for current research. As introduced in the introduction (chapter 1) modelling is a great tool used for explanation and thus understanding of complex systems [Edmonds et al., 2019]. By gaining additional understanding of the resource allocation process in chapter 2, modelling became better fitted as a research method. The agent paradigm where an agent represents some entity and completes actions or takes decisions by interacting within its environment [Dam et al., 2018], seems to suit the resource allocation process as it could be defined as a social system [Ackoff and Gharajedaghi, 2003]. In sort, the interacting management layers each operating their own processes within a common environment.

For the implementation of the agent-based model the software called NetLogo has been used. NetLogo is open source agent-based modelling software which is often used within the academic field [Wilensky, 1999]. The programming language within NetLogo is very approachable, resulting in easy adjustments if required for future work. At last the author has experience in coding with the software package, resulting in preference for NetLogo.

3.1.3 Model analysis

Analysis of the model has happened with the help of data created by several simulation experiments. These experiments have generated a lot of data which then have been analysed with the help of RStudio. RStudio is open source software based on the programming language R, and used for statistical computing and graphics [RStudioTeam, 2020]. The preference for RStudio has been based on prior usage of the software by the author.

3.2 RESEARCH FLOW DIAGRAM

In this section the research flow is illustrated with the help of a research flow diagram (figure 3.1. All executed research steps are visualised within the research flow diagram. As modelling is an iterative process, the research has been an iterative process as well.

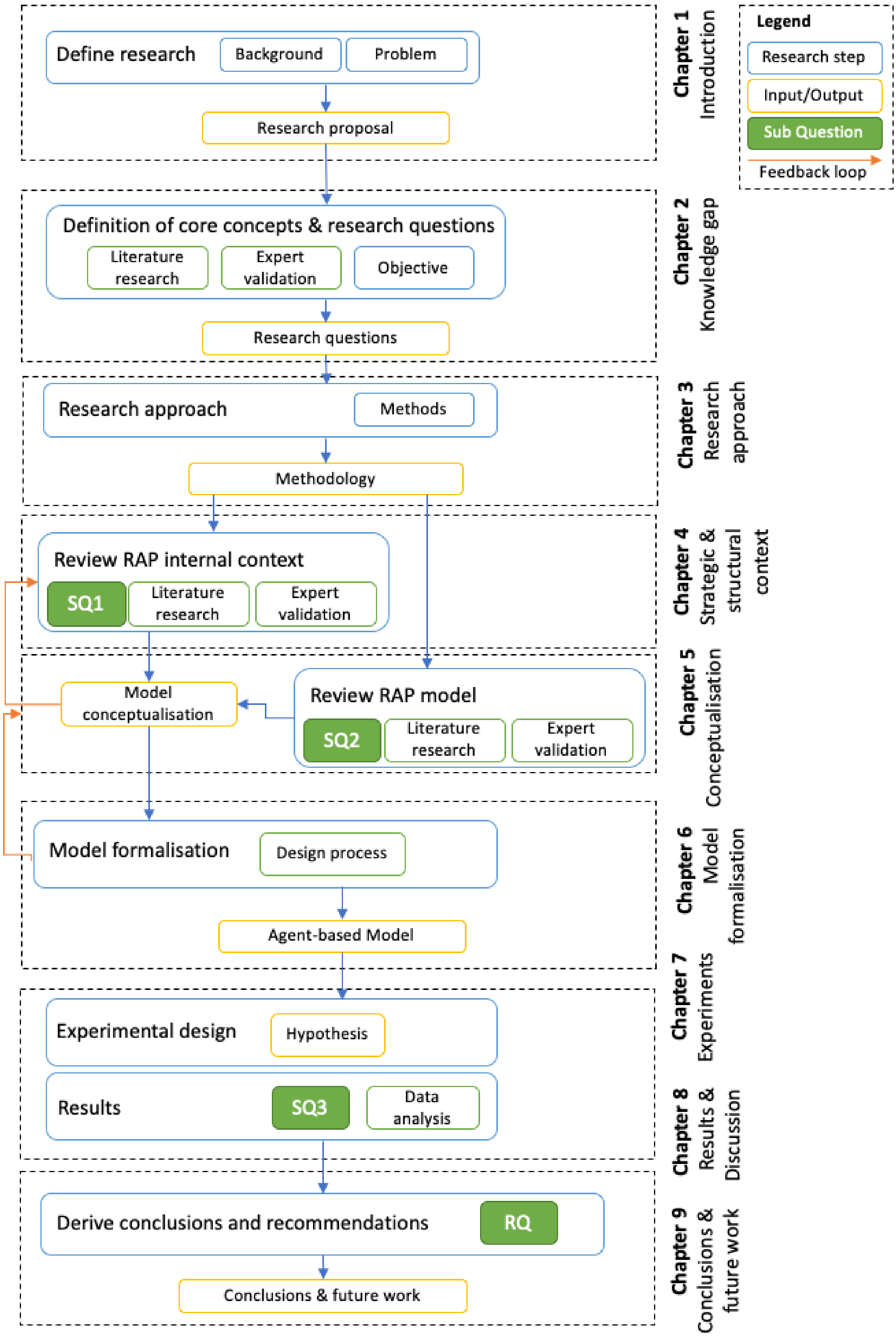

Figure 3.1: Research Flow Diagram

Research flow

Within this and previous chapters, the research topic has been introduced, core concepts and the research questions have been defined, and the research approach has been discussed. From here on the research questions will be answered. Starting with a literature research to understand he internal context of the resource allocation process. That research will focus on understanding the structural and strategic contexts and the corresponding phenomena. This desk research which will be performed by reviewing resource allocation process literature. The focus will be on defining the core of the structural and strategic context in order to conceptualise these contexts. The core needs to be defined in such a way that it can be implemented in an agent-based model. When the internal contexts are known the external contexts have to be defined. From the literature research of chapter 2 it became clear that current resource allocation literature focused a lot on the external influences and case specific explanations. As for this research the focus is more on the internal workings of the resource allocation process, which means the external context has to be defined in a sufficiently general way such that the agent-based model will facilitate in all kinds of research. The definition of the external context will also happen through a literature research. Where the focus will be on finding a creative solution to keep the external context generic but suitable to fit all kinds of further research.

Conceptualisation of the definition and selection processes from the resource allocation process will happen through literature research. Knowledge about the cognitive, organisational, interpersonal and economic facets of the resource allocation process need to be translated into an agent-based model. Therefore the conceptualisation will start with extensive literature research after which each element of the resource allocation process will be discussed. While conceptualising, the results will be validated with the help of an expert. Before turning the conceptualisation into a model it has to be formalised. Implementing the model into the software will act as a check on the completeness of the conceptualisation, if not, the conceptualisation will have to be adapted. The implementation thus provides feedback on the conceptualisation of the resource allocation process model. After implementation, several hypotheses will be constructed which will be tested by running experiments with the agent-based model. These experiments should reveal the possibilities and limitations of the model and conclude if the model will support understanding of the resource allocation process.

4 ORGANISATIONAL BEHAVIOUR: THE STRUCTURAL AND STRATEGIC CONTEXT

Before diving into the conceptualisation of the complete resource allocation process, the internal context will be discussed. The internal context defines how the allocation processes are executed and define the outcome of the processes. Within the definition of the core concepts (chapter 2) the structural and strategic context have been defined as the mechanisms which control the behaviour of the organisation executing the resource allocation process. First the outcome of the allocation process will be discussed after which the structural and strategic contexts will be defined. Finally this chapter is going to answer the following sub-question: *What mechanisms define the structural and strategic context of the resource allocation process in a way that they are suitable for conceptualisation?*

4.1 STRATEGIC ACTION

Burgelman [1983] defined the evolutionary framework (see figure 4.1). The framework shows that the structural and strategic context influence the concept of corporate strategy but also two types of strategic action. Each context is influenced by a form of strategic action, in other words, there is a feedback loop between the contexts and strategic action. Strategic action defines what the organisation actually does [Burgelman, 2002], the results of all actions are known as the concept of corporate strategy. As seen in the evolutionary framework, the bottom arrow from "concept of corporate strategy" to "induced strategic action" shows that induced strategic action is a direct result of the defined concept of corporate strategy. Induced strategic action is action which results out of the traditional top-driven view of strategic management (the boss tells his employees what to do, and how to do it) Burgelman [2002]. If actions fit within the defined corporate strategy the action will be called induced strategic action. Several examples of these actions could be "Oriented towards gaining and maintaining leadership in the companies core businesses like increase market penetration, product development, new market development and strategic capital investment projects for the existing businesses" - Burgelman [2002].

Autonomous strategic action is not linked to the concept of corporate strategy and defines initiatives from individuals or small groups that are outside the scope of the corporate strategy, but become part of the strategy when they are adapted. Autonomous strategic action typically involve new combinations of competencies that are not currently recognised as distinctive or centrally important to the firm [Burgelman, 2002]. When successful, autonomous initiatives may replace existing businesses, which could cause strategic business exits through abandonment or divestment [Burgelman, 2002].

4.2 CONTEXT DETERMINATION

Before diving into the structural and strategic context, two mechanism will be introduced; structural and strategic context determination. These mechanisms have been introduced by Burgelman [1983]. "Structural context determination reflects

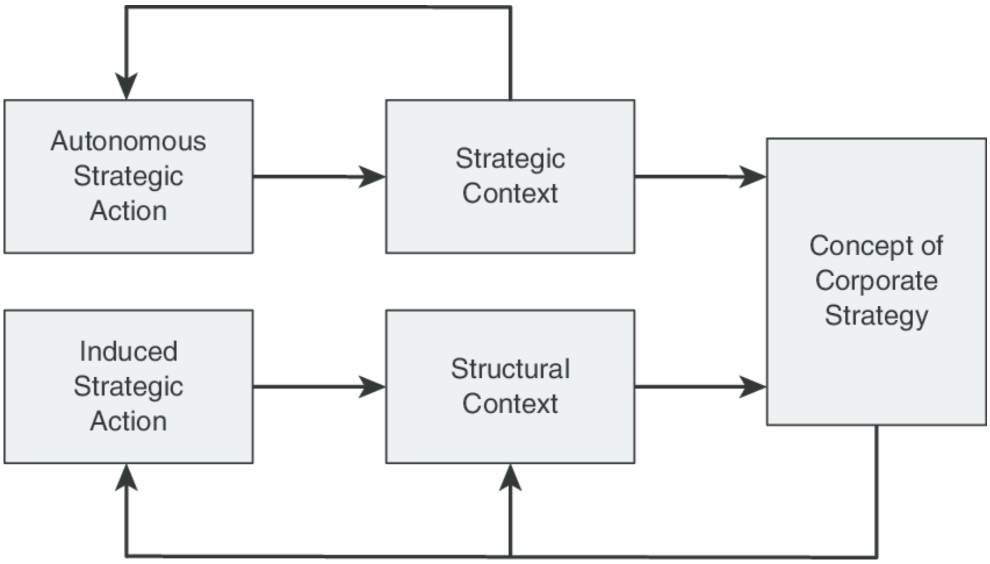

Figure 4.1: Evolutionary framework by Burgelman [1983]

the efforts of corporate management to fine-tune the selective effects of the administrative arrangements so as to keep (or bring) the strategic proposal generating process in line with the current concept of corporate strategy" - [Burgelman, 1983]. The concept of structural context determination thus results in changes within the organisation to increase their efficiency and focus on execution of the defined strategy. "Strategic context determination reflects the efforts of middle level managers to link autonomous strategic behaviours at the product/market level into the corporation's concept of strategy" - [Burgelman, 1983]. By linking the autonomous strategic actions to the corporate strategy the organisation first has to look for opportunities outside the corporate strategy. The concept of strategic context determination causes the organisation to focus on organisational learning and exploration of their environment. If determination can be defined as the effort to push the changes of the behaviour. A structural context can thus be defined as the behaviour in the organisation about efficiency and execution of the strategy. A strategic context can then be defined as behaviour in the organisation about organisational learning and exploring the environment. These concepts will be discussed in the following sections.

Before defining the structural and strategic context it is useful to mention that both contexts exist in all organisations and behave like the Chinese yin and yang [Simons, 1995b]. It is a balance between controlling the organisational efficiency and organisational learning [Simons, 1995b]. But while organisations always have both contexts, an organisation can have a preference for one context over the other.

4.3 STRUCTURAL CONTEXT

When a organisation is smaller, the link between strategic action and the concept of corporate strategy is readily maintained, simply because there are few key players, and they all know each other well. When a company grows larger this is no longer the case. Strategy making has to become distributed over differentiated groups (functional, product, geographical) and multiple levels of management. Which results in a important source of internal variation [Burgelman, 2002]. The corporate management can use the structural context to maintain the link between induced strategic action and the existing corporate strategy (the corporate strategy which they defined for their firm). Burgelman [2002] defined the structural context as - "Structural context encompasses organisational structure, planning and control systems, resource allocation rules, measurement and reward systems, among other administrative arrangements, as well as cultural aspects such as recruitment and socialisation processes and more or less explicit principles of behaviour". And Bower and Gilbert [2005] defined the structural context as "formal organisation, the way businesses are measured and the way functional and general managers are measured and rewarded". Both agree that the structural context is a mechanism which corporate management can use to maintain the link between the strategic action and the existing corporate strategy. It focuses on working efficient and obtaining the targets through induced strategic action.

For this research the structural context is defined as a mechanism used to let the organisation focus on the targets set by the corporate management. This could be done through several "variables" which can be changed by corporate management. It lets each operating- and management level focus on the corporate defined strategy. A mechanism to focus more on the set targets is with the use of diagnostic control systems [Simons, 1995b]. Diagnostic control systems focus on motivation and providing direction to achieve goals. In other words, the diagnostic control systems focus on executing the corporate defined strategy. This happens with the use of deductive analytical reasoning (flying by instrument), where there is a strict focus on setting and maintaining targets which fit the corporate defined strategies. The management sets specific fixed targets which have the intention to be achieved. Division managers function as gate keepers in the case of diagnostic control systems, and interfere if necessary [Simons, 1995b].

Another way of to create focus on the set targets is to make changes within the organisational structures. Each organisation structure has its own strengths and weaknesses. March [1994] states that hierarchical organisations use delegation and departmentalisation to mobilise diverse individuals to relative coherent action. The departmentalisation organises restrictions to the freedom of employees within a firm. Usage of organisational structures within a firm is a way of setting environmental restrictions [Simons, 1995b]. According to Simons [1995b] organisations setup more restrictions in times of environmental uncertainties. Restricting the firm to mainly focus on working with their direct colleagues can help increasing the efficiency of each division. Setting a strict environment is called "Tight control", the opposite of "Loose control" [Simons, 1995b]. It limits the freedom of their employees which results in assuring that the employees behave in a way that the firm wishes, having focus on their targets and the corporate strategy.

Finally, setting the structural context could be as simple as defining specific resource allocation rules. Defining formal rules with a specific target for specific types of expenses. Burgelman [2002] described an example within the Intel case, where the R&D-division had to maximise the output per Wafer (amount of computer-chips per raw material). Within the Intel case, in order to obtain resources for an initiative it had to very specifically contribute to maximising the output per Wafer. With this example Intel allowed no other initiatives than ones that contributed to maximising the output, in this way they restricted the available actions drastically.

4.4 STRATEGIC CONTEXT

Literature is clear about the existence of the structural context. But rarely describe the strategic context without the term "determination". For example "Strategic context determination serves to evaluate and select autonomous strategic actions outside the regular structural context, usually through the interactions of various types of champions and top management" - Burgelman [2002]. Therefore the strategic context will be defined as the behaviour which defines how the organisation behaves while evaluating and selecting autonomous strategic actions. In essence the strategic context defines how much attention they give to autonomous strategic actions. If an organisation promotes the strategic context, and thus uses strategic context determination, they promote the execution of autonomous strategic actions. Management uses strategic context determination if they are not sure about their strategic importance or the organisations competencies to successfully pursue a specific strategy [Burgelman, 2002]. Corporate management could question themselves or even question the firm competencies to successfully pursue a specific strategy. Either way there is uncertainty within the corporate management and they have to deal with it. By increasing the attention going to autonomous strategic actions they enhance the possibility of finding feasible autonomous strategic actions. When they select feasible autonomous strategic actions they adopt these actions within their strategy.

When the attention for autonomous strategic action starts growing, the organisation starts to learn more about their environment. By leveraging strategic context the organisation opens up the opportunities for their staff to start to explore and learn about their environment and seek for opportunities [Burgelman, 2002; Bower and Gilbert, 2005]. With a preference for a strategic context there is focus on organisational learning instead of focus on efficiency and targets. Focus on organisational learning is the core of the strategic context. Encouraging organisational learning happens through a couple of things. As described by Johnson et al. [2008] organisational learning is more likely to happen in a informal setting, where social interaction is encouraged. The mindset of the organisation needs to change so they continuously challenge themselves. Experimentation becomes the norm, so ideas have to be tried out and become part of the learning process. In order to leave room for these changes to a learning organisation there needs to be room for the political process of bargaining and negotiation. This happens through releasing control, by which they leave room for organisational slack [Johnson et al., 2008].

The mindset of organisational learning has overlap with the interactive control systems of Simons [1995b]. The interactive control systems leave room for more creative search, stimulation of dialogue and analytical reasoning is inductive (flying by feel). A few examples of mechanisms which are often paired with organisational learning and interactive control systems are inductive analytical reasoning, stimulating dialogue, focus on the future and re-estimating targets [Simons, 1995b]. According to Simons [1995b] the focus with interactive control systems is on the present and future of the firm. Working together and constantly re-estimating the targets motivates the employees to get to their targets and if the targets have been set too optimistic, the targets could be re-evaluated. In a more strategic context, the staff has a role of facilitator and is supposed to support the teams in order to obtain their targets. Simons [1995b] describes this as maximising the Return On Management, the standard organisational procedures need to occur without constant management oversight. When they are able to work in that way, management can focus on ways to improve collaboration between their employees and organisational learning which results in creative search. An example is the inductive analytical reasoning where previously successful managers probably come with more successful ideas, resulting in more trust in those managers. Management can then link the successful managers to less successful managers or teams in order to stimulate the organisational learning. Which in fact is just stimulating dialogue between the right employees. But next to that they could give their employees more freedom in their focus on a specific topic, resulting in a larger opportunity space [Simons, 1995b]. Combining dialogue and a broader opportunity space results in creative solutions which will increase the amount of autonomous strategic actions. Having a diverse team, and stimulate dialogue across divisions is described by the diversity bonus of Page [2017]. Page describes that a diverse team based on cultural background, study and gender provides a bonus within the organisation. The differences lead to creative solutions and tackling problems from different perspectives [Page, 2017]. With the increase of dialogue, the result will be more creative ideas which likely do not match the corporate defined strategy, which is often exactly what was the reasoning as it solves for the earlier discussed uncertainty of corporate management.

Creative solutions placed outside the corporate strategy are autonomous strategic actions, so for a good performing manager it would be useful to promote dialogue outside the comfort of their own division.

The strategic context can thus be determined through releasing control, meaning that the control on targets and efficiency need to be released. By releasing control, the organisation creates organisational slack, resulting in room for experimentation and negotiation. As autonomous strategic actions are a result of social interaction within an informal setting it would be necessary to encourage interaction between employees. With these mechanisms the culture and behaviour within the organisation is likely to change to a mindset where employees try continuously challenge themselves and learn more about their environment.

4.5 CONCLUSION

This chapter discussed the important strategic action which results in the executed strategy. Autonomous strategic action is both influenced by and influences the strategic context. And the induced strategic action is both influenced by and influences the structural context. Corporate management is able to define the context which suits their situation. If they have a clear vision and defined corporate strategy, it might be best to focus on a structural context and thus stimulate induced strategic action. When corporate management questions their own strategic importance or the organisations competencies to successfully pursue a specific strategy, it could better focus on a strategic context and thus stimulate autonomous strategic action.

This chapter started with the following sub-question *What mechanisms define the structural and strategic context of the resource allocation process in a way that they are suitable for conceptualisation?* The structural context is used to maintain control between the corporate strategy and the induced strategic actions. The strategic context defines how the organisation leaves room for autonomous strategic actions. Both contexts thus define the extent of control versus organisational learning. Corporate management can use the structural context to increase control within the organisation by creating focus on targets, minimise room for experimentation, restricting communication and changing the mindset to focus on strategy execution. The strategic context could be encouraged through; creating organisational slack by releasing control on the targets, encouraging communication, and the change to an experimental organisational mindset.

5 CONCEPTUALISATION OF THE RESOURCE ALLOCATION PROCESS

In the previous chapter the most important part of the resource allocation process was discussed, the strategic and structural contexts, in this chapter that conceptualisation is extended to the full revised resource allocation process by Bower and Gilbert [2005]. It describes the resource allocation process as a simplification of the real world. Before going into the allocation processes the resource allocation process itself will be briefly discussed, to create understanding of the main purpose of resource allocation. The resource allocation process will then be defined in a schematic model. Then the agents which live inside the model will be discussed followed by the processes they execute. After definition of the processes, other relevant concepts and the model environment will be defined. Finally the sub-question: *What conceptualisation describes the resource allocation process suitable for model implementation?* will be answered within a conclusion of the chapter.

5.1 SIMPLIFICATION OF THE RESOURCE ALLOCATION

For this research the desire is to define an agent-based model of the resource allocation process by Bower and Gilbert [2005] (figure 2.1) in order to investigate the inner mechanisms of the complex reality. The process is briefly introduced through the basics of the process. In its most simplistic form it is a basis for allocating capital (money) within an organisation to business cases that have a positive outlook, in other words business cases likely to generate money for the organisation. There are many different types of business cases imaginable to invest in. These could be specific projects, departments or even people, the possibilities are endless. The possible business cases are called investment opportunities. The investment opportunities are defined and selected trough several processes within the organisation, which operates within a specific market. These processes are executed by three different management levels, in hierarchical order: corporate, middle and operational management. Each management level has its own responsibilities. Together they execute strategic actions through allocating resources. The actions they take are based on observations of the market. The resource allocation process is thus all about spending the limited amount resources wisely, which is not as easy as it sounds. Allocating your resources wisely, means deciding on which actions you spend your resources.

5.2 SYSTEMATIC MODEL

In figure 5.1 a systematic model layout of the resource allocation process is presented. Three types of agents are visualised within the figure; corporate, division and venture. Each responsible for their own processes. The information flow is indicated with the arrows and the interaction is indicated with the dotted arrows. The information flows from strategic action to the external context and from the external context back to the organisation, that information flow is a feedback loop and indicated through the looped arrows. The output of the model is defined by the strategic action, which is a result of the agents interacting with each other. The strategic action can be defined as the emergent property[1] of the agents. The following sections will introduce the agents, processes, concepts and environment within the schematic model of the resource allocation process.

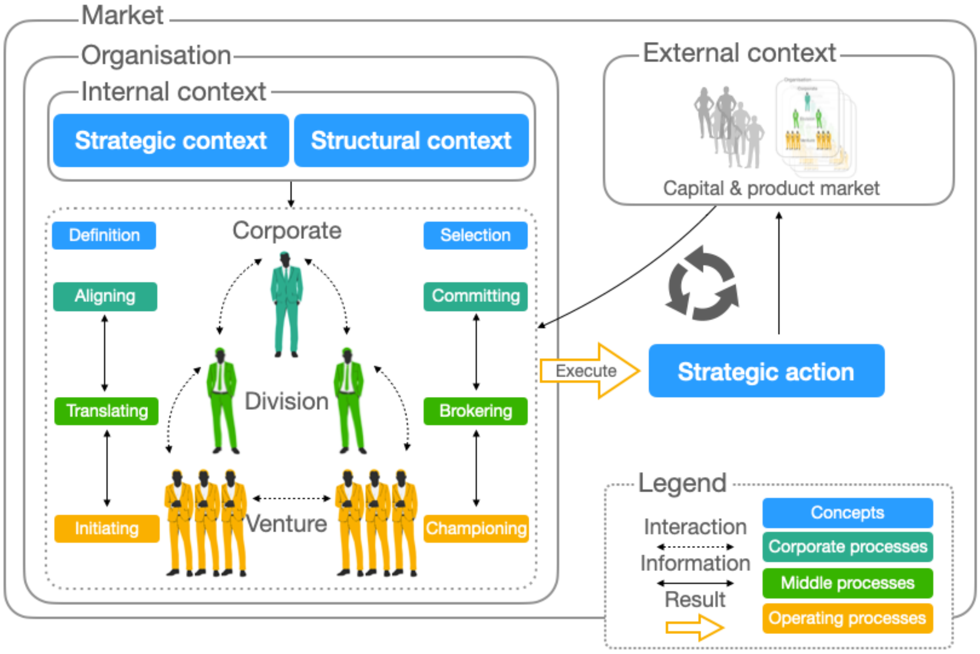

Figure 5.1: Schematic model layout of the resource allocation process

5.3 AGENTS IN THE RESOURCE ALLOCATION PROCESS

The resource allocation process model of Bower and Gilbert [2005] defined three management levels; corporate, middle and operational. Each management level plays its own role within the resource allocation process. Within the schematic model layout, the management levels have been translated to agents; a corporate manager, division managers and venture leaders. In this section the agents will be discussed.

5.3.1 Corporate manager

The corporate management is a team (or person) which runs the organisation, this team has the final responsibility. In the end the corporate management is responsible for continuity and growth of the organisation they manage. Because the corporate management operates as one team, the corporate management has been defined as one agent; the corporate manager. The corporate manager manages continuity and growth through allocating the resources to the right divisions. So if the corporate manager manages their resources well, the organisation might grow or at least survive in their environment. The allocation of the resources, the selection process at the corporate level, is referred to as the committing process, the process where they assess resource applications. But before assessing and committing the applications they should define what they expect from their employees. The definition of what they expect from their employees happens in the aligning process. There they match the strategy to their current situation and they define what subjects would suit the organisation best. For theses processes the corporate manager

1 Emergent properties: "Properties that can not be understood by just looking at the properties of the individual components, but are created as a result of the structure and organised interactions between these components" - [Dam et al., 2018]

needs to know where the organisation is working on, their performance and how much resources he can spend. Within these processes he communicates with his division managers.

5.3.2 Division managers

The middle management level is represented by the division managers. They are responsible for the Translating and Brokering processes within the organisation. The division managers translate the global corporate strategy, received from the corporate manager, to actual goals and targets for their own division. Each division has its own specialisation and the division managers need to translate the corporate strategy to division specific strategy and target. They communicate the defined division strategy and to their venture leaders. For the brokering process they judge initiatives proposed by the venture leaders in their division. The division managers judge the initiatives on feasibility and selects which initiatives have priority. The division manager then requests resources from the corporate manager. The division managers function as a broker between the corporate management and the venture leaders. The division managers play a large role in selecting the initiatives which suit the organisation. Their preferences depend on the context they operate in. But in the end, it should be all about maximising the profit by making the right bets. For the translating and brokering processes they use the performance of their division, their divisional budget, cognitive abilities and targets.

5.3.3 Venture leaders

The operational management level of the resource allocation process is represented by the venture leaders. They are employees within a specific division and thus share the characteristics of a specific division. The venture leaders are responsible for the initiating, championing and the execution processes. Within the initiating process they look for opportunities to invest in, these are called initiatives. Within the championing process they decide which initiative is feasible and would be best to invest in, they thus select an alternative and champion this to their division manager. While doing this they can communicate with their direct colleagues or in special occasions their friends from outside their own division. Within the execution process they execute the approved initiatives. The initiatives get approved if they receive resources from their division manager for the initiative they championed. For execution of the processes processes the venture leaders use their cognitive abilities, the strategy they receive from their division manager, their own performance, a target and their friends.

5.4 PROCESSES OF RESOURCE ALLOCATION

This section explains and conceptualises the two kinds of processes happening in the resource allocation process. As seen in figure 5.1 the processes are divided into two types: *definition* and *selection*. Bower [1970] defined two kinds of processes in the resource allocation process, the definition process and the impetus process. Eventually Bower and Gilbert [2005] re-defined the two kinds of processes as *definition* and *selection*. The *definition* processes at different levels of the organisation are Aligning, Translating and Initiating. And the *selection* processes are Committing, Brokering and Championing.

5.4.1 The aligning process

The aligning process is a process which is executed once a year by the corporate manager. Within the aligning process the corporate manager is responsible for alignment of the strategy and action. Over time the corporate manager assembles the distinct strategic actions to a strategy [Burgelman, 2002]. Alignment happens on industry factors and firm specific factors [Sengul et al., 2019]. He defines in which direction he wants the organisation to go with the help of strategy definition, but also makes sure that the divisions support each other. The corporate manager thus has to unite the organisations actions into one direction. He uses the organisations performance to define which strategies work and the financial alignment happens through definition of targets.

5.4.2 The translating process

The translating process is managed by the division managers, they translate the corporate strategy into division specific measures. They integrate corporate and business unit thinking [Bower, 2005]. This translation happens to instruct their venture leaders who in turn go and look for opportunities. A strategy could be defined as venture leader specific or one for the entire division. This fully depends on the type and preference of the organisation. The translating process is a continuous process during the year. The division managers thus create guidelines for the venture leaders so the venture leaders know what is expected, when and by whom. Examples of the guidelines are, targets, required return on investment, time-span of the project, subjects and the acceptable level of risk. The guidelines are determined with the help of the corporate strategy, division performance and venture leader performance. The division manager communicates guidelines to their venture leaders as a specific strategy they should follow and a target they should obtain. The division managers also support their venture leaders through pointing them to specific directions.

5.4.3 The initiating process

The initiating process is where venture leaders of an organisation start their search for investment opportunities [Bower and Gilbert, 2005]. They start this search after their division manager tells them to, so without instruction the venture leaders do nothing. They use the input of the translating process in order to know what is expected from them. In order to look around for investment opportunities the venture leaders need to have some sort of direction, which is the strategy they get from their division manager. Within the initiating process they define their investment possibilities. The initiating process thus is the process where the venture leaders are looking for opportunities to invest in. These opportunities could be different kinds of projects differing from optimisation projects to starting new product lines. Each time they get in a new situation, by changing the initiative they are working on, they have to scan their environment in the search for new investment opportunities. The degree of freedom within the organisation defines how much venture leaders are allowed to deviate from their core business.

5.4.4 The championing process

Championing is the process where the venture leaders take a decision which opportunity, defined during the initiating process, they want to execute [Bower and Gilbert, 2005]. The venture leaders only execute the championing process if they initiated any investment opportunities. They then place their judgements on the available possibilities, which they initiated in the initiating process [Burgelman, 2002]. When a venture leader decides he is going to champion an initiative, he is convinced that the initiative he picked is the best he could pick. He then tries to convince his division manager and others that the initiative he picked is truly worth investing resources in. Interaction within this process is important, the venture leaders discuss the initiative they have in mind with their colleagues. Discussing with their colleagues through both formal and informal ways increase the chance of success of their proposed initiative [Axelrod and Cohen, 2001; Bower and Gilbert, 2005]. Another benefit of discussing the initiative with their colleagues is that their colleagues might have recommendations of other possible interesting initiatives. (Un)fortunately not all venture leaders are free to communicate as they like. The ability of being able to discuss the initiatives with their colleagues depends on the organisational context. If venture leaders would discuss every option of investing resources with the entire organisation, the organisation would lose its efficiency. While not discussing could result in reinventing the wheel. In order to conceptualise the championing process, there is thus some form of communication and restriction required and the venture leaders have to be able to judge several initiated initiatives with the help of their cognitive abilities.

5.4.5 The brokering process

The brokering process is a process in which the championed initiatives are adopted by the division managers. They place their judgements on the championed initiatives from their venture leaders and present this to the corporate management [Bower and Gilbert, 2005]. The role of the division managers executing this process is limited, as they do not have the knowledge or information to evaluate the initiatives on their merits so they have to rely on the data provided by the venture leaders [Bower, 1970]. Placing their judgement in real life relies on many different factors and not just a cost benefit judgement, it needs to match with the organisations strategy. In fact, the selection process taking place in the brokering process is a multi-criteria decision-making problem. Which means that there are different criteria which play a role in the decision-making process, what these variables are, is dependent on the organisation. For example, the subject of a championed initiative plays a critical role in the selection procedure. To illustrate this: "it makes no sense for the local butcher to invest in a new car tyre balancing machine (as it does not match with his core business). He could better use his resources to invest in a new more economical refrigerator or something else, related to his business". The division manager keeps the organisations strategy and targets in mind while judging each championed initiative with the help of his cognitive abilities.

5.4.6 The committing process

The committing process is where the resources get allocated. Committing resources is an annual process, executed by the corporate management. One way of dividing the resources is dividing equal parts to the divisions but literature agrees that spreading resources in some formulaic fashion across all divisions was poor corporate strategy [Burgelman, 2002]. According to Burgelman [2002] the companies allocate their resources to businesses (divisions) rather than specific projects. Therefore the divisions have to present a plan of what initiatives they are going to execute with their required resources. "Capital is typically allocated in a hierarchical and cascading manner. Funds are provided to a particular business unit (division), which in turn makes allocations to specific initiatives and activities" - [Levinthal, 2017]. Thus, after the corporate management has decided which divisions get what amount of resources, the division managers have to divide the resources to their venture leaders and corporate management will have to trust the judgement of the division managers.

5.4.7 Time span of the processes

The timescale of the resource allocation process can also differ a lot between organisations. For this research the assumption has been made that organisations divide their resources to their divisions once a year. One year is therefore the largest time-step in the conceptualisation. From the processes which are executed during the resource allocation process, the smallest time-step would be each quarter. The processes which happen each quarter of a year are translating, initiating and championing. These processes make that the resources which are divided once a year are invested in proposals which suit the organisation.

5.5 INTERNAL CONTEXT

As discussed in chapter 4, the internal context influences the way the agents act within the system. The structural and strategic context define the behaviour of the organisation. Usually the behaviour of the organisation comes from within the organisation. For this research the model needs to serve a purpose to research the relationships within the resource allocation process. Therefore the definition of the internal context happens through definition by the modeller instead of from within the organisation itself. The contexts need to be defined through increasing and releasing control, restricting and encouraging communication, and changes within the organisations mindset.

5.6 EXECUTING STRATEGY

Based on the outcome of the resource allocation process, the realised strategy, the venture leaders now have to actually execute their plans. If the venture leaders received resources to execute their plans, they can execute their plan and thus take strategic action. If they did not receive resources, they have to come up with another plan or wait until their plan is worth the investment. By executing the plans the actual corporate strategy gets defined [Burgelman, 2002]. The planned strategy becomes reality as the strategic actions are executed, actual investments have taken place.

5.7 STRATEGIC ACTION

The outcome of the resource allocation process are the executed initiatives, these are the ones that the entire organisation agrees are worth investing in. As discussed in chapter 4, the execution is called strategic action. To recall, the strategic actions are subdivided into autonomous strategic action and induced strategic action. Both strategic actions appear in all organisations, but the number of either autonomous or induced actions reveal if the process is organised as planned. Therefore the strategic actions count as the real output of the resource allocation process which Bower and Gilbert [2005] defined as the realised strategy. This means that the output is directly linked to the initiatives constructed at the initiating process. The external context then provides feedback on the executed strategy whit which the agents can adapt their strategy. In order to illustrate this with an example: an initiative executed through the resource allocation process, is always a risk (investing in something where you are not sure if it provides you with the expected payoff). If the market is interested in the investment then they will react positively on the investment and this generates resources for the organisation. If the reaction of the market is negative it could cost the organisation resources, in other words, it was a bad investment. The realised strategy can thus be conceptualised as an executed plan that provides the external context with information to react on in the form of providing resources to the simulated organisation or costing the organisation resources. Providing the resources delivers feedback to the organisation and therefore the feedback loop has been defined in the schematic model (figure 5.1).

Furthermore the strategic actions, as defined in chapter 4, have two types: autonomous and induced. The difference between these strategic actions define the outcome of the resource allocation process. As the all agents work together to execute these strategic actions, it can be defined as their emergent property.

5.8 THE EXTERNAL CONTEXT

Within the revised model of resource allocation by [Bower and Gilbert, 2005] the capital market and product market context are specified. These have been defined as the external context by Sengul et al. [2019] and have been adapted in the schematic model (figure 5.1). The organisation operates in a market where all possible customers, suppliers, capital providers and competitors of the firm, define the external context. The external context thus defines the behaviour of the environment the organisation operates in. The external context reacts on the strategic actions executed by the organisation. The reaction would be through providing resources (buying the initiative) or costing resources (not buying the initiative or worse unexpected costs). The response of the external market on the executed strategy decides if there is positive or negative feedback on each executed initiative. Over time the reaction of the external context could change. An example would be the reaction of the market on a new product, at first it could be a great success but that success could fade. e.g. a disk-man, once a great success but now the streaming services are the standard for music on the go. The concept of the external context thus is that it needs to provide **feedback**, needs to be **dynamic** and should provide many different **opportunities**.

5.9 CONCLUSION

Within this chapter the basic principles of the resource allocation process have been discussed. The actors of the allocation process have been defined and conceptualised to agents which live inside the model. The processes which the agents execute have been defined and the relevant concepts are discussed. The sub-question which this chapter had to answer is: *What conceptualisation describes the resource allocation process suitable for model implementation?*

The resource allocation process can be conceptualised through definition of three agents: a corporate manager, division managers, and venture leaders. These agents interact while executing the resource allocation processes. They execute these processes within an environment which allows them to search for investment opportunities, provides feedback and be dynamic. The outcome of the model is defined with the strategic actions taken by the agents in the model, which could either be autonomous or induced strategic actions.

6 FORMALISATION OF THE MODEL

Within the previous chapter the conceptual model has been defined. This chapter defines how, and in which order, the agents execute the processes within the simulation. Before formalising the conceptualised processes and concepts, the model environment will be introduced. The formalised model environment is required for understanding of the formalised processes. After the formalisation of the model environment, the sequence of the model will be discussed. All processes will then be formalised resulting into an overview of model variables and explanation of the model setup. Finally the output variables will be discussed. The code of the implemented model is available in appendix F, and will not be discussed in this chapter.

6.1 MODEL ENVIRONMENT

Before defining when each agents interacts within the model, the environment of the model will be formalised. Within chapter 5, the external context has been conceptualised as the behaviour of the simulated organisation environment. The requirements of the conceptualised environment are that it facilitates the simulation to provide **feedback**, **investment opportunities** and be **dynamic**. With the combination of multiple investment opportunities and the required feedback it should deliver, a rugged landscape as used by Levinthal [1997] could be an option for formalisation of the external context. A rugged landscape is a landscape where there are several peaks and valleys divided over a landscape. So instead of a landscape with only x- and y-coordinates the landscape also has a corresponding z-coordinate. This means that each peak within a rugged landscape has a positive z-coordinate, while the valleys have a negative z-coordinate. If assumed that a positive z-coordinate represents positive feedback, then a negative corresponding z-coordinate represents negative feedback. Levinthal [1997] used this principle and defined the height of the z-coordinates as fitness levels. For this research the fitness could represent the performance indicator of the benefits of a specific point in their environment. The performance indicator of a specific coordinate in the modelled environment will therefore be called the fitness value. The venture leaders can now move across the landscape and explore the simulated environment. Each coordinate represents an investment opportunity, so each move within the landscape will cost the organisation resources. This means that an opportunity further from a venture leader requires more resources to invest and consumes more time compared to a close-by opportunity. Figure 6.1 illustrates this formalisation. The venture leader can move through the environment. Moving towards opportunity A or B would cost him three investment opportunities, while moving towards opportunity C would cost him just one investment opportunity.

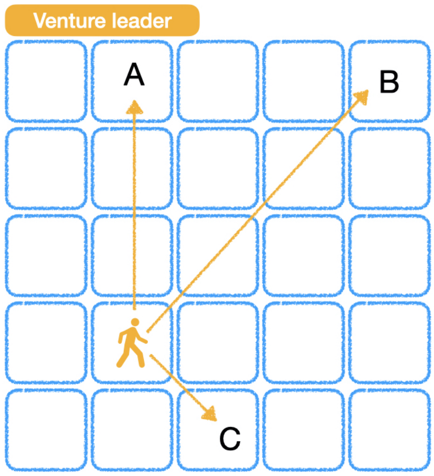

Figure 6.1: Formalisation of investment

The external context had to provide feedback, to the simulation according to the height of a specific location in the landscape. The feedback has been defined as the fitness value of a specific coordinate. An example of the landscape which is used for this thesis is given in figure 6.2. Within this figure the peaks represent a positive feedback to the model, while the valleys represent a negative feedback to the model. The venture leaders operating in the model strive towards obtaining the highest fitness value. The actual landscape can be changed easily in order to suit the specific experimental setup. How much resources the venture leaders obtain for the organisation can also be changed easily. This happens through setting the variable Type of income to *Total fitness* or *Delta fitness*. With Type of income set to *Total fitness* the venture leaders receive the fitness value as resources for the organisation. With the variable set to *Delta fitness*, the venture leaders receive the total fitness minus their starting fitness value as resources.

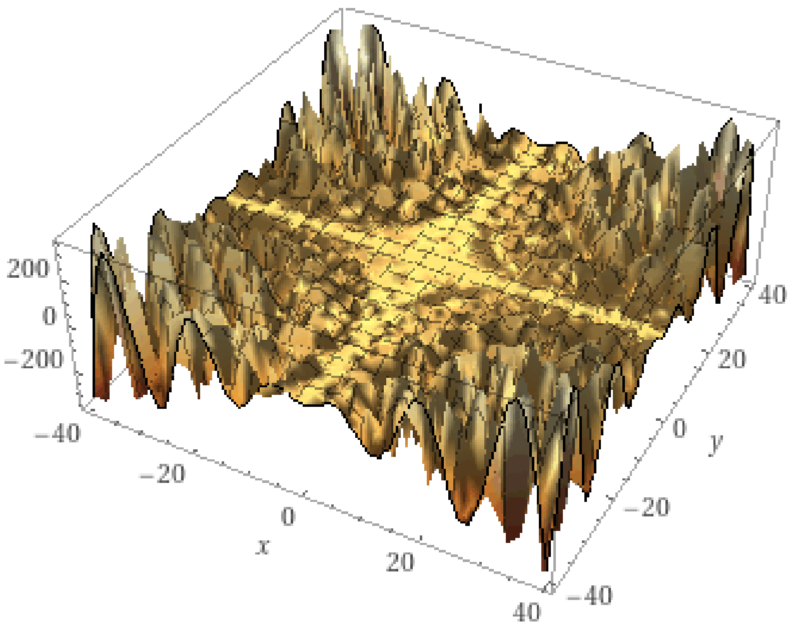

Figure 6.2: 3D plot of rugged landscape

At last the environment needed to be dynamic. The dynamic aspect of the environment will happen through input of a variable called exhaust factor. The exhaust factor will define the fitness which gets subtracted from a specific coordinate if the venture leader is on that specific coordinate. The subtracted value will then be randomly distributed within the environment. Within the real world the interest in a product will also shift, and not disappear. Therefore the subtracted fitness value will be randomly distributed.

To conclude, the environment has been defined as a fitness landscape where each xy-coordinate has a corresponding fitness value. A positive fitness value delivers positive feedback to the organisation (provide resources), while a negative value delivers negative feedback (cost resources). The dynamic aspect of the landscape happens trough subtracting fitness value from a coordinate, and randomly distribute it to another coordinate.

6.2 MODEL SEQUENCE

The processes of the model, executed by the agents, have been defined in section 5.4. The sequence of execution of these processes are introduced in figure figure 6.3. The agents follow the sequence of these processes during the simulation. Each process starts after the agents are finished with the previous process. Within figure 6.3, the box with tick has been added into the sequence of the processes. A tick is a unit of time within the model, and for this research represents a quarter of a year. The first process to run after starting a simulation is the *Aligning* process, executed by the corporate manager. Then the steps as visualised in figure 6.3 will be taken. The sub-processes are coloured to the agent(s) who execute the processes, but the agents are also visualised right above their specific processes. The processes within the red box, *brokering*, *committing* and *payout*, are only executed once a year (so once every 4 ticks). The rest of this chapter defines the processes in detail, a sequence diagram in more detail is available in appendix A.

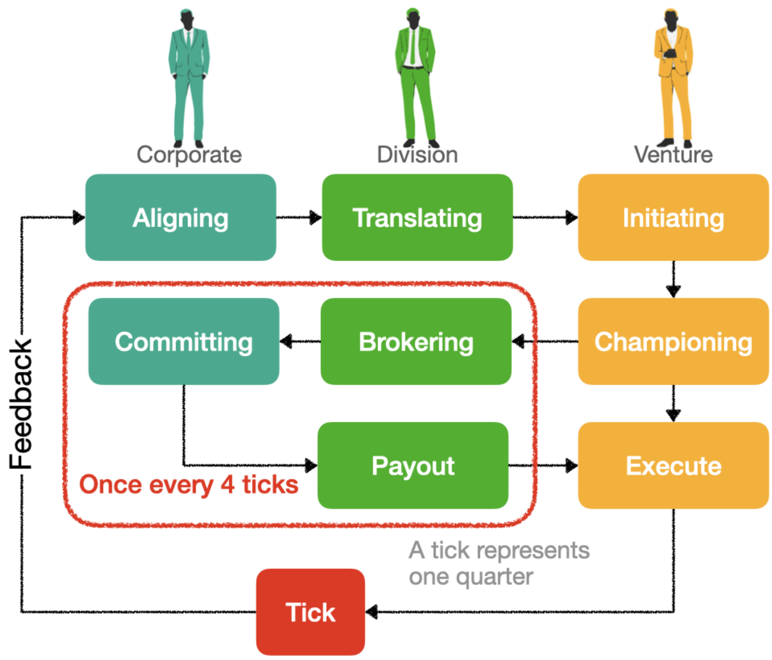

Figure 6.3: Sequence of processes

6.3 ALIGNING

The aligning process has been conceptualised as getting the organisation to work together to one common goal. Within the model this happens through annual definition of the corporate strategy. The corporate manager agent starts the aligning process by asking his division managers to give him an update of their performance. The division managers in turn ask their venture leaders about their current fitness status. When the corporate manager receives the status of the divisions he sets a new target for the entire organisation. The target is based on the average fitness of the organisation. The corporate manager then communicates the target to the venture leaders.

6.4 TRANSLATING

The translating procedure is executed by the division manager, who gives instructions to his venture leaders (see figure 6.4). The division manager translates the corporate strategy to their specific division. The target they received from the corporate manager gives an indication of what is expected by the corporate manager. The venture leader then defines a division specific strategy based on the defined "organisational slack" [March, 1994]. The organisational slack defines the area around the target which are allowed within the corporate strategy. The boundaries have been defined as the variables minimum percentage of average fitness and maximum percentage of average fitness. If the division fitness gets above the upper bound, the division has to stop. Do they get below lower bound, the manager needs to take action (see figure 6.5). The

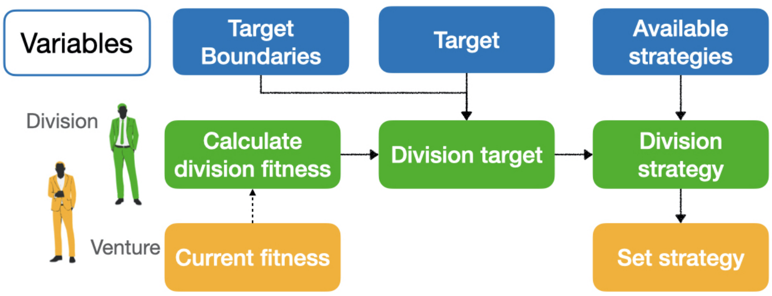

Figure 6.4: Translating in short

This translating process is thus set up as management by exception. The division managers let the venture leaders do their work while they perform in a certain range. This range is defined by the lower and upper-bound, as illustrated in figure 6.5. These bounds have been set by the modeller, but in the real world would be set by the corporate management. These bounds are part of the aligning process, in the real world the corporate management would align on more than only the targets. Due to the conceptualisation of the fitness landscape, resulting in projects as coordinates with a corresponding fitness level, the alignment can only happen on the fitness levels. Therefore the alignment happens through these boundaries. The division managers take this alignment and set a specific strategy for each division. Although there are three "levels" of fitness as illustrated in figure 6.5, there are four strategies available for the division manager. These strategies will be discussed in subsection 6.6. In the end the venture leaders receive an instruction for a strategy they should use and they set their strategy accordingly.

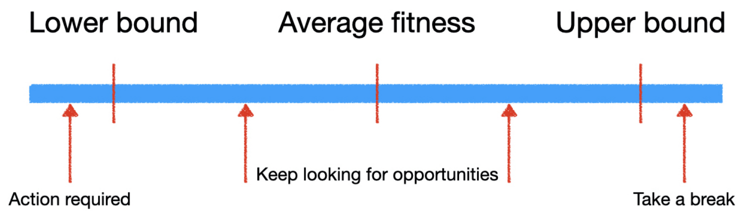

Figure 6.5: Range of fitness levels

6.5 INITIATING PROCEDURE

The venture leaders execute the initiating process, what a venture leader in the real world goes through is a review of where they are, followed by a careful review of what investments they could make. In the simulated process, the venture leaders go through a similar process, the review of where they are is simulated by their position in the fitness landscape, the investments they can review is determined with a variable called viewing range. The viewing range would normally be determined by the strategy and set by the division manager, but in the simulation this is done by the modeller. The venture leaders thus review all investment opportunities around them within the viewing range. The possible options for investments are represented by steps in the fitness landscape where the farther you step the higher the cost and the fitness landscape itself determines the expected benefit of the step.

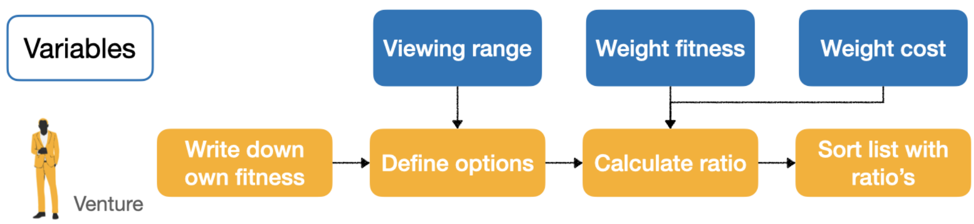

Figure 6.6: Initiating in short

Reviewing the possible investments usually happens through a simple cost-benefit analysis. The benefits are, to the best of his knowledge, judged with the help of his cognitive properties. The benefits can thus be reviewed differently by different venture leaders. As the benefits are represented by the fitness value there would be no difference in judgement, the decision weights can change the judgement of the venture leaders. The actual judgement is calculated by the venture leader with the help of equation 6.1. With a preference for fitness, the simulated venture leader is risk tolerant, while a preference for cost results in a risk averse venture leader. So the decision weights are usually set through the cognitive properties, in the model it is set by the modeller. In addition to the possibility to set the level of risk tolerance, there is an option to create diversity within the simulated venture leaders risk tolerance. By setting the model into the diversity mode, the modeller is able to create venture leaders which have different preferences. The difference in preference can be controlled by the variable weight divergence. An explanation in more detail is provided in appendix C.

$$Ratio = 1 + \frac{fitness}{maxfitness} w_{fitness} - \frac{cost}{maxcost} w_{cost} \tag{6.1}$$

6.5.1 Communication

Communication is not a predefined process within the resource allocation process by Bower and Gilbert [2005], but communication is a critical process within the resource allocation process. Venture leaders communicate with their colleagues and their manager, their manager communicates with the corporate management and vice versa. The venture leaders communicate their current fitness and location to their division managers each tick. The division managers then communicate the maximum fitness and corresponding coordinates to each venture leader within their division. As communication is usually restricted within an organisation a specific modelled process should allow the communication between venture leaders. The communication has been conceptualised to a specific range (Communication range), but also to a limited time frame. The memory venture leaders have about their colleagues outside their division, can be restricted by the variable Link memory. For the communication between venture leaders whom are not within the same division, links are used. A link is a connection between two agents. Which gets created at the moment the venture leaders are working close by each other. How close they should work to each other is depending on the set variable Communication range. When the link is created, the venture leaders can communicate with each other, even if they are on the other side of the simulated world. Just like in the real world, the saying ”out of sight, out of mind” also happens in the simulated world. At the moment the venture leaders are no longer in each others communication range, a timer starts counting. If the counter matches the set Link memory the relationship dies. If they get back within each others communication range, the timer gets reset.

6.6 CHAMPIONING

The championing process is executed by the venture leaders. The championing process starts with the venture leaders checking if they executed they previous championed initiative. Their previous championed initiative should be executed before they champion a new initiative. The venture leaders call the successfully championed initiatives their Personal Plan. If they finished executing their plan they start the championing process. The main point of the championing process is the strategy [1] the venture leaders received from their division manager during the translating process. Within the championing process the venture leaders take a decision about which investment they would like to make. Which decision they make fully depends on the strategy they received from their division manager. The division manager has to choose from four strategies: Pick best around, Walk straight, Specific action or Stand still. Before elaborating about each strategy, it is important to know which strategy gets assigned in what situation. The strategy selection is visualised in figure 6.7 and the strategies are explained in the following sections. Remember figure 6.5, where there are three levels of fitness. Now there are four different strategies which could be assigned. The strategy pick best around is assigned in the case of keep looking for opportunities. This is the base strategy as defined for the current model, the division is performing better than the lower bound and worse than the upper bound. If a division is performing better than the upper bound, the organisation would like to allocate the resources to less performing divisions. So the strategy, when performing better than upper bound, will be to stand still. If a division is performing worse than the defined lower bound, there are two options. The first option, is that the entire division is under performing which results in the strategy walk straight. Second option, there is one (or more) venture leader which performs as expected which results in the strategy specific action. As

1 It should be mentioned that the strategies defined in this section are assumptions. The strategies are the result of an iterative process, which fitted the conceptualised alignment.

the championing process depends on the type of strategy, each strategy and the corresponding championing process will be explained.

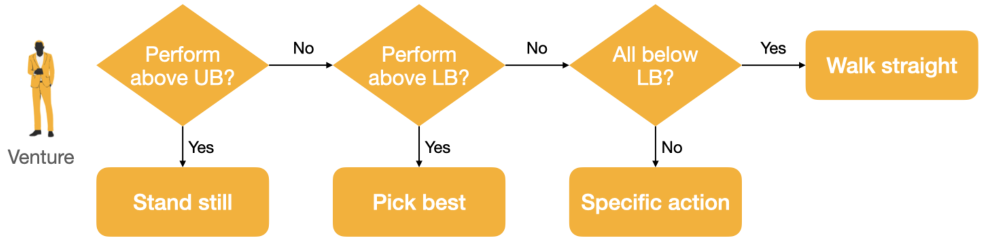

Figure 6.7: Strategy selection

6.6.1 Strategy: Pick best around

Pick best around is the base strategy where the venture leaders have a fitness level between the lower and upper bounds. The venture leaders scanned their environment in the initiating process and mapped each ratio of the surrounding patches. They have remembered the calculated ratio and the corresponding coordinates of all patches within the defined viewing range. Within the strategy Pick best around the venture leader has to pick the best patch he is able to "see" (within his viewing range). There are thus two things the venture leader can do. If all other options are worse than the patch where he is currently standing, he has to decide to stay where he is. Or if a patch within range is better than his current patch, then he can decide to champion that patch. When championing a patch, it doesn't matter which one he picks (could also be the patch he already stands on), the venture leader has to set his personal plan. Within his personal plan he notes the calculated ratio, the fitness value and the coordinates. He then also sets his personal plan name. The personal plan name is a personal venture leader variable which notes the decision he has made. This is in order to keep track of the decision a specific venture leader has taken.

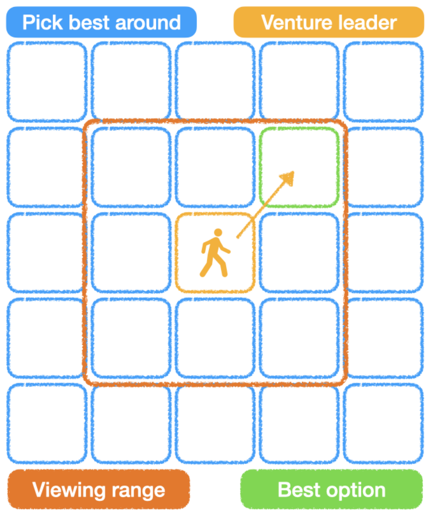

Figure 6.8: Strategy pick best around

6.6.2 Strategy: Walk straight

The intention of the strategy is that the division manager needs to interfere with the venture leaders as the entire division has no clue of the landscape. They thus need to explore the landscape and find something which suits their target. With this strategy all venture leaders within that division need to walk in a straight line, exploring the landscape. They do this until the amount of steps taken forward meet the variable *FD Count (forward setting)*, which puts a maximum to the amount of steps which can set in the straight line. If the counter is matched with the set maximum, the venture leaders need to change direction. The change of direction happens randomly and the counter is reset. The strategy to pick a random direction is quite risky as they randomly discover their environment. But this strategy is only activated at the moment the division is out of options, they start taking risk when they perform worse than the acceptable range of performance March [1994]. When championing starts, the venture leader is supposed to pick the patch right in front of him. He sets his personal plan name variable to "walk straight" and sets his personal plan to the patch in front. But this might not be the best decision, luckily the venture leader also thinks by himself and checks if the best patch in range (remember the list of the initiating process) meets the set target. If the best patch in range is meeting the target, the venture leader ignores the strategy and sets his personal plan to the specific patch. The personal plan name gets set to "Found a patch in range" and his variable personal plan gets set to that specific patch. In this case the venture leader is not working according the allocated strategy and he did something different. The venture leader thus performed an autonomous action. The global output counter *"Self championed autonomous"* gets incremented with 1. The venture leaders variable (AutonomousAction?) which tracks if he has performed an autonomous action, gets set to "Self championed autonomous".

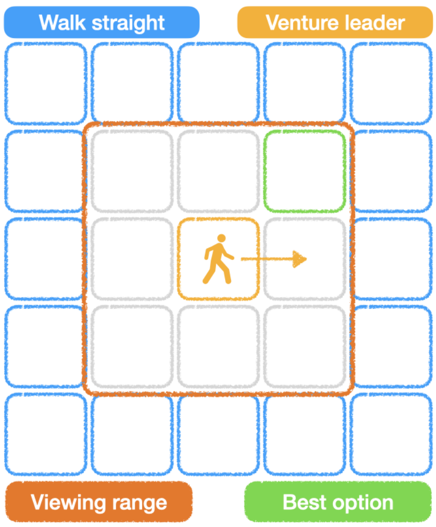

Figure 6.9: Strategy walk straight

6.6.3 Strategy: Specific action

The core of this strategy is that the division manager orders his venture leaders to move to a specific patch. While the venture leaders need to move to that specific patch, they keep looking for opportunities on their way there. If they find a better location elsewhere they go somewhere else. But before following the direct order of the division manager they check if they can find a better solution. The venture leaders check within their division which patch would suit their needs and delivers the best calculated ratio. They also contact their colleagues outside their division that they have links with. They check if one of their colleagues has a better option for them than the patch proposed by the division manager. Eventually the venture leaders will champion the option with the best calculated ratio. They thus have a few options within this strategy. Some follow the strategy, others are defined as autonomous actions.

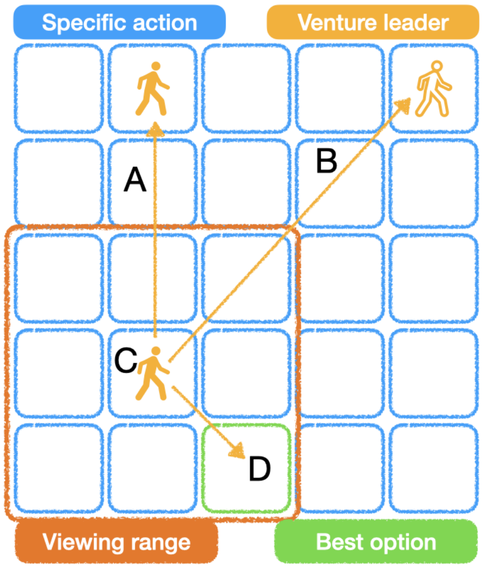

Figure 6.10: Strategy specific action

AVAILABLE OPTIONS FOR SPECIFIC ACTION

A. Divisional colleague has the best option. The venture leader sets his personal plan name to *"Specific action"*, and his personal plan to the corresponding coordinates. His variable AutonomousAction? gets set to *"Strategic Induced"*

B. Colleague outside his division has the best option. The venture leader sets his personal plan name to *"Specific action"* and the personal plan to the corresponding patch. The variable AutonomousAction? gets set to *"Other championed autonomous"* and the global variable Other championed autonomous gets incremented with 1.

C. The venture leader is already on the best patch he knows. The venture leader is thus supposed to stay where he is. Personal plan name gets set to *"Stand still for now"*, the personal plan gets set to his current location. AutonomousAction? gets set to *"I'm already there"*.

D. The best patch known to the venture leader lies within the viewing range, and is not the patch he is currently standing on. The personal plan name gets set to *"Specific action"* and the personal plan gets set with the corresponding patch. AutonomousAction? gets set to *"Self championed autonomous"* and the global variable Self championed autonomous gets incremented with 1.

6.6.4 Strategy: Stand still for now

The strategy stand still for now will be allocated by the division manager if his division has a fitness above the upper bound of the average fitness see figure 6.5. In that case the division is performing above expectation of the firm. The division performing above expectation needs to take a break which gives the rest of the firm an opportunity to catch up. These divisions which perform above expectations also take care of a steady income of resources. These resources can then be used to support the less performing divisions.

6.7 BROKERING

Brokering is part of the selection process, this is where the division managers place their judgement on each championed initiative. Within chapter 5 it became clear that this selection procedure had to become a multi-criteria decision. As it is difficult to place a judgement on something which only has a certain fitness value, and specifically no subject, other measurements had to be defined. With the possibilities and the judgement of an expert in the field the following decision variables have been defined:

1. Current fitness of the venture leader. This variable will be minimised as the division manager should prefer investing in a venture leader with a low current fitness. In this way a under-performing venture leader is likely to be allowed an investment opportunity, which is a common phenomenon at conglomerates (the stronger are helping the weaker).

2. Expected fitness delta, in the end it is all about obtaining the highest fitness value. Therefore the expected fitness delta is an important decision variable.

3. Performance (or success rate) of the venture leader, the success rate of the venture leader shows how much fitness the venture leader has realised compared to the resources he has spent. This is an indication for the division manager what the track record of this specific venture leader is.

4. Uncertainty of the investment, a venture leader can champion an investment that he is not sure about, this uncertainty or risk. If this variable is important to the division manager, it means investments with high uncertainty are unlikely, and the division manager is set to be risk averse.

5. Requested budget size, as there is a limitation of available resources this variable should be minimised. Therefore the division manager has a preference for championed initiatives that have a lower cost.

These variables are being used by the division managers to place their judgements on the committed initiatives. The decision variables are used to calculate a decision ratio. The higher the ratio, the better a specific initiative fits the expectations of the division manager. The modeller should define the weights for each variable. The weights should sum to a total of 1. As it is difficult to come up with a weight out of nothing the best-worst method by Rezaei [2015] will be used. With the help of the method the modeller can put in exact values in the simulation.

6.7.1 Calculating the ratio

When the importance of each variable is known the division managers can judge the championed initiatives. This subsection will define how the projects are being judged during the simulation. As defined in chapter 5 all championed initiatives are judged by the division managers, each division manager does this for their own division. The venture leaders provide them with all the information they need. Which means that the venture leaders provide the division manager with all the data to calculate the ratio. Calculating such a ratio requires using normalised values which makes it possible to compare the ratios of each championed initiative.

Within equation 6.2 all decision variables have been called $w_{variable}$ the w stands for weight, the factor which defines the importance of the variable with the help of the best-worst method [Rezaei, 2015]. Before each noted $w_{variable}$ there is a normalisation of each variable. This normalisation takes place for a comparison within the division. So the numerator of each fraction is the value of the venture leader who championed the initiative. While the denominator of each fraction is the maximum value within his division. These normalised values are then multiplied with the weighted values (the importance of the variable) and summed (variable which need to be maximised) or subtracted (variable which need to be minimised) so the result becomes one number. The value of this number represents the judgement of the division manager. The higher the number the more successful that specific championed initiative should fit the needs of the organisation. The division manager then writes down the ratios, requested budget and the increase in fitness. He adds the total ratio and total requested budget and asks the corporate manager for the required budget.

$$
\begin{aligned}
Ratio = 1 - \frac{Currentfitness}{Maxfitness} w_{fitness} + \frac{\Delta fitness}{Max\ \Delta fitness} w_{\Delta fitness} \\
+ \frac{Performance}{Max\ performance} w_{performance} - \frac{Uncertainty}{Maxuncertainty} w_{uncertainty} \\
- \frac{requestedbudget}{Maxbudget} w_{budget}
\end{aligned}
\tag{6.2}
$$

6.8 COMMITTING

Within the committing process, the corporate management looks at the judgement of the division managers. They have to pick what investments proposals get resources to execute the projects and then provides resources to the divisions with the best plans. The committing procedure is set to happen once every simulated year. The corporate manager checks how much resources he can divide between his divisions. The order of dividing his resources is fully depending on the judgement of the division managers. The division with the summed highest judgement get all their requested resources at first. After which the division with the second highest judgement gets their resources. This continues until either there are no more resources left, or all divisions received resources. When the committing process has been executed the payout process will start.

6.8.1 Payout

The payout process is actually part of the committing process. But for modelling purposes it has been separated so it becomes clearer where the payout happens. The payout process is executed by the division managers, who received budget from the corporate managers. The budget they received is being divided between their venture leaders. The division manager has the list with calculated ratios and the amount of resources each venture leader requested. The payout happens in order, according the score of the ratios. Each venture leader gets the resources he requested, unless the amount of resources obtained by the division manager is not sufficient. Then the venture leader gets the amount of resources which are left. If the venture leaders receive resources, they are able to execute their championed initiatives. The moment they receive their resources they have to note this. If they had their personal variable Autonomousaction? set to *"Other championed autonomous"*, the global variable Other executed autonomous will count one additional other executed autonomous action. This is the same for *"Self championed autonomous"* and then the variable Self executed autonomous will count the action. In this way there can be tracked what kind of actions are executed.

6.9 EXECUTE

Execution of the championed initiatives happens through the venture leaders. If a venture leader received resources from his division manager, he will execute his investment proposal. The championed initiative will be executed by the venture leader. For this process the personal plan name variable is used. If the personal plan is called *"Stand still"* or *"Stand still for now"* the venture leader knows he does not have to perform any action within the execute process. If the venture leader has *"Walk straight"* as a personal plan name, he picks the coordinate right in front of him. He then walks there and subtracts the cost of an investment from his resources. If the personal plan name is *"Specific action"*, *"Pick best around"* or *"Found a patch in range"*, the venture leader sets his direction towards the coordinate he championed. Before taking a step towards the coordinate he planned to go to, he checks if the planned location still has a better fitness than the coordinate he is currently on. If this is false, he stays where he is. If the planned coordinate still has a better fitness, he then puts a step towards his planned destination, and resets his location to the middle of the coordinate. He also subtracts the cost of his investment from his resources.

Then a part of the feedback starts. Despite an executed investment, all venture leaders check if the type of income is set to *Total fitness* or *Delta fitness*. To recap, if the type of income is set to *Total fitness* the venture leader receives the total fitness value in resources. If the variable is set to *Delta fitness* the venture leader receives the fitness value minus the value he started the simulation with. The venture leader then gives the resources to his division manager, who in turn hands the resources to the corporate management. It is also possible that the venture leader takes a step on a coordinate with a negative fitness. Then the organisation has to pay additional resources and resources get subtracted from the general resources account. If the landscape setting has been set to *Dynamic exhausting* each coordinate that has resources subtracted, will lower his fitness value. The amount of fitness that gets subtracted by the venture leader will be multiplied with the "exhaust factor". The fitness value of that specific coordinate will get subtracted with the calculated value.

6.10 MODEL SETUP

This section provides an overview of the variables used within the model. These variables have to be set before starting the simulation. The section then briefly introduce how the agents get distributed within the landscape.

6.10.1 Setting the variables

Before setup of the model the contextual settings have to be set according to the insights of the modeller. Setting the variables which are required for the world to be created and simulated are defined within table 6.1. These variables create a lot of possible setting, which provides the modeller with the ability to simulate a lot of different situations. As seen in table 6.1, the variables are grouped.

Some examples of the general firm variables would be setting the size of an organisation, resulting in a small or large number of venture leaders or divisions. The division manager variables set the behaviour of the division managers. Having all these possibilities makes the model suitable for a lot of different purposes. While setting the variables the modeller should keep in mind what he would like to research with a simulation and specifically what the situation of the firm is, he would like to simulate. A researcher could also use this to validate the robustness of assumptions across different types and sizes of organisations.

General Firm variables	Division Manager (DM) variables	Venture leader variables	External context variables
Number of divisions	DM starting fitness target	Weight fitness	Kind of landscape
# venture leaders / division	Weight DM uncertainty	Weight cost	Landscape
Firm reserves	Weight DM current fitness	Viewing range	Cost of investment
Min % of average fitness	Weight DM delta fitness	Communication range	Type of income
Max % of average fitness	Weight DM budget	Link memory	Exhaust factor
Firm starting resources	Weight DM performance	Forward setting	
Weight divergence			

Table 6.1: Variables to set before simulation.

6.10.2 Creating the agents

As defined in chapter 5 there always is one corporate manager and this can not be changed by the modeller. The number of divisions has to be selected by the modeller and this defines the number of division managers. The division managers get randomly distributed within the landscape. Randomly distributing the division managers results in a different starting environment for the divisions. The amount of venture leaders per division is also defined by the modeller. The venture leaders starting point in the simulation is in a perfect circle around their division manager. Which results in a different starting location for each venture leader. There also is an option to create diversity between the agents, this happens through activating the variable heterogeneity? in combination with the variable weight divergence. The weight divergence influences the heterogeneity of the agents and determines how much they differ from the original settings of the decision variable weights(an explanation in more detail of the divergence mechanism is provided in appendix C). After all agents are created, each venture leader also maps who his division colleagues are and remembers this during the entire simulation.

6.11 OUTPUT VARIABLES

As discussed in chapter 5, there are autonomous strategic actions and induced strategic actions. Both are measured within the simulation. Next to the strategic actions also the resource levels, costs and total executed investments are measured.

6.11.1 Autonomous strategic action

Autonomous strategic action, or actions which do not follow the concept of corporate strategy should be measured within the simulation. The autonomous strategic actions are measured on three levels. The initiated autonomous strategic actions, the championed autonomous strategic actions and the executed autonomous strategic actions. From each of these three levels of autonomous strategic action the simulation counts all actions, which result in a cumulative value at the end of the simulation. For each of the three autonomous action levels both the self- and other-autonomous actions are counted. With the distinction in self- and other-autonomous actions the output will be able to define where the autonomous actions come from.

INITIATED AUTONOMOUS ACTION occurs when the venture leader initiates some patches while the initiated patches do not match with the strategy set by their division manager. This happens when the venture leader has the strategy *"Walk straight"* and a venture leader initiates the patches around him, in other words he is not following the set strategy. Another possibility is that the venture leader has the strategy *"Specific action"* he is supposed to walk to a patch of one of his division colleagues, mentioned by his division manager. Within this strategy he evaluates the options with all his known contacts and initiates autonomous initiatives which he received from others. So this would be called an other-autonomous strategic action.

CHAMPIONED AUTONOMOUS ACTION occurs when the venture leader has the strategy *"Specific action"* then he needs to walk to a patch of one of his division colleagues, mentioned by his division manager. When he reevaluates the patches of his division colleagues he also looks around him for other options. He checks with his "friends" outside his division. If the venture leader picks a patch to go to from his "friends" (Links in the model), it would be called championed autonomous action.

EXECUTED AUTONOMOUS ACTION are the initiatives that get to be executed after a venture leader received resources. This could be either Self championed autonomous action or Other championed autonomous action. Where self means a result from the self initiated, and other is a result from the other initiated.

6.12 CONCLUSION

Within this chapter the conceptualisation has been translated into the formalisation. It discusses the sub-processes of the resource allocation process in a level of detail which can be implemented into an agent-based model. The formalisation resulted in a rugged fitness landscape which provides feedback to three kind of agents: a corporate manager, divisional managers, and venture leaders. The venture leaders trek through the fitness landscape by interacting with their colleagues and superiors. Each time they change their location they execute an investment, which costs the organisation resources. The executed investments either provide or cost the organisation resources. How much resources is depending on the fitness landscape. With this formalisation several experiments will be conducted, these should reveal if the model behaves as expected. The location of the implemented model can be found in appendix F.

7 EXPERIMENTAL DESIGN

Within this chapter experiments will be defined in order to test the functionality of the constructed model. Before definition of the experiments the contextual settings will be defined. The contextual settings are set to extreme values which will not be representative within a real world situation. Setting the contextual settings to extreme cases will provide recognisable situations to compare model expectations with the simulation outcome. After defining the setup for the contextual contexts, several hypotheses will be defined. These hypotheses will be based on the expected outcome of situations resulting in definition of the experiments.

7.1 DIVISION MANAGER DECISION VARIABLES

As explained in chapter 4, the mindset of the organisation has to be changed to change the context of the organisation. This section will define the mindset of the division manager, which in turn defines the extreme context of the simulated organisation. Within the experiments the decision variables of the division managers will have two kinds of settings. Either an extreme strategic context or an extreme structural context. These settings will be the same for **all executed experiments**. Setting the division manager decision variables required to think in the extreme context settings. Determining the exact values of the decision variables is done with the help of the Best-Worst method as discussed in chapter 6. Using this method many assumptions had to be made. As a result of chapter 4, strategic context determination is about organisational learning and exploring their environment. Structural context determination is more about efficient execution of the corporate strategy, and therefore a focus on obtaining the set targets. With the outcome of each context in mind, the importance of the decision variables has been made. First the motivation for the values will be described after which the decision variables are presented in table 7.1.

SETTING THE EXTREME STRATEGIC CONTEXT DECISION VARIABLES resulted in the assumption that the delta fitness is most important for a case with extreme strategic context. Trying to come up with the best possible investment would be preferred. Of secondary concern is the performance of the venture leader. This is according to the inductive analytical mechanism, in which status of the venture leader would matter [Simons, 1995b]. This is much less important than the delta fitness as prior results would not seem to be all-embracing. After performance the budget would play a role in the investment, management would still take budget in serious consideration. The current fitness is not so important in the extreme strategic context, as described in section 6.7. The current fitness weight is to have preference for venture leaders which do not have a high fitness as there is a lot room to grow. So in the case of the pure strategic context there is less preference for venture leaders with a low current fitness value, as obtaining their target does not really matter as much as in the pure structural context. At last the uncertainty has been scored as the least important, as it is all about organisational learning.

SETTING THE DECISION VARIABLES FOR A EXTREME STRUCTURAL CONTEXT, it is assumed that the most important decision variable would be the current fitness.

Having preference for the venture leader which has the lowest fitness value, will help the division to obtain their target. After that there is aversion of uncertainty, resulting in uncertainty to be the second most important. The division manager would like to know for sure that his investment is delivering the result he expected. After that the budget is looked at from the division managers perspective and shortly after that the past performance of the venture leader plays a role. The least important decision variable would be the delta fitness, so the increase in fitness value. As it is just about obtaining their targets and if there is more, it would be great but the target should be met first and foremost.

Table 7.1: Division manager decision variables per **extreme context**[a]

Weight	Delta fitness	Performance	Uncertainty	Current	Budget
Strategic	0.48	0.20	0.05	0.12	0.15
Structural	0.06	0.10	0.21	0.51	0.13

[a]: These contexts are not realistic for a real world case and used to test the phenomena

7.2 CONTEXT INFLUENCES STRATEGIC ACTION

According to the theory of the evolutionary framework of Burgelman [2002], the strategic context influences autonomous strategic action. While a structural context influences induced strategic action. As the strategic and structural context are phenomena which are both within an organisation, the following extreme hypothesis is purely theoretical and would not exist in the real world. The hypothesis: *A simulation setup which has full focus on the strategic context, would result in more autonomous strategic action when comparing this to a full focus on structural context.* An experiment of these extreme conditions should reveal if the mechanisms implemented in the agent-based model behave like the evolutionary framework of Burgelman [2002].

THE EXPERIMENT IS SET to test extreme cases of structural and strategic context within the model. The extreme cases of structural and strategic context are tested in order to test an important phenomenon in the resource allocation literature (the phenomenon as discussed in chapter 4). In order to test this phenomenon the variables have to be set to the extreme cases of structural and strategic context. For the extreme strategic context the situation which would be expected is the mechanism of organisational learning, which suits the interactive control theory of Simons [1995b]. While for the extreme structural context the situation which would be expected is a focus on targets and looks more like the diagnostic control systems. The effect which needs to be measured is the number of autonomous strategic actions. By monitoring only the amount of executed strategic actions, it would not be possible if the preceding actions contain autonomous strategic actions. Within the model there are several types of actions measured. All autonomous strategic actions are measured, and even subgroups of those actions are measured. Furthermore all executed initiatives are measured. The autonomous strategic actions are divided into three sub-actions: Initiated, Championed and Executed autonomous strategic actions. From within these three actions a division has been made into self and other. Self means that the agent which executed the action, used his own collected data. Other means that the agent which executed the action used data he received from others in the simulation.

Setting the context defining variables for the organisation it is thought to either have focus on the targets, or to promote organisational learning. The actual values of the settings have been noted in table 7.2. For the pure strategic context a value of 70 for the target lower bound has been set. There is quite some space for the venture leaders to perform under the set target. While for the pure strategic context the division manager will interfere quite soon, already if the division manager is performing 10% under the set target. For the upper bound of the target within the pure strategic context setting the venture leaders get quite some freedom, while within the pure structural context the venture leaders are cut off a lot sooner. The viewing range has been set to a large value within the extreme strategic context. Resulting in the venture leaders having more freedom in opportunities to pick from, thus learning more about their environment. For the extreme strategic context the communication range has also been set to a large value, resulting in more communication with their colleagues. For the extreme structural context where the focus lies on obtaining targets, the distraction of a lot of opportunities is minimised. Thus the viewing and communication range are kept small for the extreme structural context. The decision variables of the venture leaders have been set to a range of settings. Where within the strategic context there is more preference for the highest achievable fitness level, while in the structural context there is more attention on the expenses. In addition on table 7.2 the weight fitness variable shows [0.5 0.1 0.8] this notation means that the variable is set to 0.5 and increases with 0.1 until 0.8 is reached. The same for the structural context setting resulting in the testing the variable with values: 0.2, 0.3, 0.4 and 0.5.

Table 7.2: Context defining variables of experiment 1

Variable	Target LB	Target UB	View	Comm.	Weight Fitness
Extreme strategic	50, 70, 90	40, 50	5	20	[0.5 0.1 0.8]
Extreme structural	50, 70, 90	5, 10	2	5	[0.2 0.1 0.5]

The following other variables (see table 7.3) have been set to an assumed standard setting. These will not change over time but are required to be set in order to run the model. The exhaust factor has been set to a variable setting, as it was unclear how the model would react to it. Therefore both the strategic and structural context settings have been tested with the variable exhaust factor. The amount of divisions and venture leaders have been set according to feedback by an expert in the field of resource allocation research (W.P.H. Kolk). Link memory has been set to 5 years (20 ticks), as this just seemed a reasonable assumption. Variables start budget, firm reserves, cost of investment, forward setting and start target, have been set after initial exploration of the model. The variables mean and standard deviation patch increase will not be used within this experiment.

Table 7.3: Other variables of experiment 1

Variable	Value		Variable	Value
Kind of landscape	Dynamic		Divisions	4
Landscape	Igor		Venture leaders	6
Exhaust factor	[0.1 0.1 0.5]		Link memory	20
Mean patch increase	-		Forward setting	25
Std dev patch increase	-		Start target	50
Firm starting budget	50,000		Actual max?	True
Type of income	Delta fitness		Stop?	True
Firm reserves	1,000		Debug	False
Cost of investment	150			

While exploring the model (running a lot of one-off simulations) it has become clear that there is a lot of variation within the model. Therefore quite some repetitions are needed. This is very common with an agent-based model and an agent-based model could never be trusted on a single run. Unfortunately simulating the model takes computing time, so there is a limitation to the number of repetitions. Therefore this experiment will run 100 repetitions per setting, in this way there is some sort of clarity of the direction of average values. The results of this experiment can be found in chapter 8.

7.3 CONTEXT PERFORMANCE IN A DYNAMIC ENVIRONMENT

According to Burgelman [2002] the strategic context is important when corporate management is unsure about their strategy, or when they are unsure about the competencies of the organisation for pursuing a planned strategy. In the case that corporate management is unsure about their strategic importance, they find themselves in a complex environment. Within the model there is an option for a dynamic landscape, which has a changing environment that represents a complex environment. According to Burgelman [2002], the strategic context influences the amount of autonomous strategic actions. With the autonomous strategic actions the uncertainty of the corporate management gets resolved as the venture leaders will take the lead on what the strategy should be. Therefore this hypothesis will state: *Within the model, in a dynamic environment more strategic context will perform better than more structural context.* The hypothesis will be tested through testing both contexts in a simulated dynamic environment. The outcome of the simulation will have to be compared based on the survival rate of the simulations. The frequency of survival rate within these contexts should reveal which type of organisation will be able to better cope in a dynamic environment.

SETTING THE EXPERIMENT requires that the model will again be set to the extreme context settings. But now the simulation will run with these settings in a dynamic landscape setting, which results in a continuously changing environment. In order to measure the performance, the survival rate is measured. The survival rate is measured through the time the organisation is functioning (so the simulation is not stopped). There are a few reasons why the simulation stops. The most important reason is that the simulated organisation goes bankrupt, if there are no more resources left the simulation stops. The second reason is when the venture leaders are no longer able to find suitable investments. Resulting in the best investment they can find, is an investment they already executed. Last reason why the simulation can stop is the maximum run time of a simulation. The maximum run time is set to 320 ticks, which represent 80 years of simulation time. The maximum run time has been based on the assumption that it is not worth looking further than 80 years in the future. The context variables have been set according to table 7.4, the other variables have been set according to table 7.5.

Table 7.4: Context defining variables of performance in a dynamic landscape

Variable	Target LB	Target UB	View	Comm.	Weight Fitness
Extreme strategic	50, 70, 90	40, 50	5	20	[0.5 0.1 0.8]
Extreme structural	50, 70, 90	5, 10	2	5	[0.2 0.1 0.5]

Table 7.5: Other variables experiment 2

Variable	Value		Variable	Value
Kind of landscape	Dynamic		Divisions	4
Landscape	Igor		Venture leaders	6
Exhaust factor	[0.1 0.1 0.5]		Link memory	20
Mean patch increase	-		Forward setting	25
Std dev patch increase	-		Start target	50
Firm starting budget	50,000		Actual max?	True
Type of income	Delta fitness		Stop?	True
Firm reserves	1,000		Debug	False
Cost of investment	150			

7.4 THE EFFECT OF OPPORTUNITY SPACE

The opportunity space, as defined by Simons [1995a], defines a set of opportunities that an organisation can identify given its competencies and resources. The opportunity space is defined by the innovation potential, existing assets and customer base, organisational skills, competencies and ability to react to the external context [Simons, 1995b]. Increasing the opportunity space, increases the amount of opportunities which can be considered while making a decision for investment. With a larger number of opportunities to consider the organisation would thus learn a lot more about its environment when compared to a small number of opportunities available. With a large opportunity space, it would be much more difficult to have focus on the set strategy. There is much more distraction which could lead to diverge from the set strategy. Diverging from the set strategy leads to autonomous strategic actions. Therefore the following hypothesis is formulated: *An increase in opportunity space within the agent-based model, would increase the number of autonomous actions within the simulated organisation.*

THE EXPERIMENT for testing the model on an increasing opportunity space will happen through increasing the viewing range. The viewing range can be seen as the amount of skill, competencies and degree of freedom allowed to use these skills. The venture leaders are thus able to oversee a larger number of potential initiatives and get more freedom in terms of organisational subjects. As the theory describes that organisational learning will increase with an increasing opportunity space, it would be useful to also test the differences in the strategic and structural context. The division manager decision variables for the strategic and structural context variables are set according to table 7.1. The context defining variables will be set according to table 7.6. The viewing range has been set to a range of settings, which results in outcomes for each of the different viewing range settings. When analysing the data, the different settings of viewing range can be compared. The measured outcome will be the amount of autonomous strategic actions per simulation. The other variables are set according to table 7.7.

Table 7.6: Context defining variables for viewing range experiment

Variable	Target LB	Target UB	View range	Comm. range	Weight Fitness
Extreme strategic	50, 70, 90	40, 50	[1 1 5]	20	0.6
Extreme structural	50, 70, 90	5, 10	[1 1 5]	5	0.4

Table 7.7: Other variables experiment 3

Variable	**Value**		**Variable**	**Value**
Kind of landscape	Dynamic		Divisions	4
Landscape	Igor		Venture leaders	6
Exhaust factor	[0.1 0.1 0.5]		Link memory	20
Mean patch increase	-		Forward setting	25
Std dev patch increase	-		Start target	50
Firm starting budget	50,000		Actual max?	True
Type of income	Delta fitness		Stop?	True
Firm reserves	1,000		Debug	False
Cost of investment	150			

7.5 THE EFFECT OF COMMUNICATION

In chapter 4 the increase in dialogue is a part of the structural context. The influence of dialogue has been defined as an increase in organisational learning. An increase in dialogue should therefore also influence the autonomous strategic actions as the venture leaders would learn more about their environment and thus discover where they should search for the best opportunities. The hypothesis states that *an increase of the communication range will increase the amount of autonomous strategic actions.*

THE EXPERIMENT for testing the model on the increase of autonomous strategic actions will require an experiment with an increasing communication range. As the theory describes that organisational learning will increase with an increase in dialogue, it would be useful to also test the differences in the strategic and structural context. When testing the differences for both strategic and structural context a conclusion could be if it really influences the autonomous strategic actions. The division manager decision variables for the strategic and structural context variables from table 7.1 are used. The other context related variables are set according to table 7.8. As these settings should only show the influence of the communication range, the communication range is the only variable which will change during the experiments. The other variables will be set according to table 7.9. The output measured will be the autonomous strategic actions for each simulation. The autonomous actions for this experiment will be divided into self- and other- autonomous strategic actions in order to be able to define if the communication has the expected outcome.

Table 7.8: Context defining variables for communication range experiment

Variable	Target LB	Target UB	View range	Comm. range	Weight Fitness
Extreme strategic	50, 70, 90	40, 50	5	[5 5 20]	0.6
Extreme structural	50, 70, 90	5, 10	2	[5 5 20]	0.4

Table 7.9: Other variables experiment 4

Variable	**Value**		**Variable**	**Value**
Kind of landscape	Dynamic		Divisions	4
Landscape	Igor		Venture leaders	6
Exhaust factor	[0.1 0.1 0.5]		Link memory	20
Mean patch increase	-		Forward setting	25
Std dev patch increase	-		Start target	50
Firm starting budget	50,000		Actual max?	True
Type of income	Delta fitness		Stop?	True
Firm reserves	1,000		Debug	False
Cost of investment	150			

7.6 THE EFFECT OF DIVERSITY

Heterogeneity within organisations could differ per organisation. There is a known phenomenon that managers like to hire people who look like them, resulting in a more homogeneous organisational structure. Page [2017] described the diversity bonus, where a more diverse team could lead to creative solutions for complex problems. Testing the extreme environments of hypothesis 1 with heterogeneous division managers and venture leaders should reveal the influence of the heterogeneity. According the diversity bonus there should be more initiated autonomous action for a heterogeneous environment. Therefore the following hypothesis is formulated: *Diversity between the agents in the defined agent-based model would increase the amount of autonomous strategic action.* Simulating the organisation with several diversity settings should reveal if the heterogeneity indeed increases the amount of autonomous strategic actions.

THIS EXPERIMENT will test the influence of heterogeneity within the agent-based model on the outcome of autonomous strategic actions. Testing this requires the model setup to include the weight divergence variable to be set. This variable has been formulated in order to define the difference between the venture leaders and the division managers. The difference between the agents is formulated by the difference in preferences, which in this thesis are called the decision weights. While the diversity bonus of Page [2017] does not discuss the level of diversity which is required in order to visualise the bonus, a range of percentages will be tested. While testing the effect of heterogeneous agents within the simulation, it would be interesting to see if they behave similar for each extreme context. Table 7.10 shows the settings for the context defining variables. The basic settings for the division manager decision variables are reused as defined in table 7.1. The weight divergence variable will cause the degree of diversity to occur. The other variables are set according table 7.11.

Table 7.10: Context defining variables of experiment 5

Variable	Target LB	Target UB	View	Comm.	Weight Fitness
Extreme strategic	50, 70, 90	40, 50	5	20	[0.5 0.1 0.8]
Extreme structural	50, 70, 90	5, 10	2	5	[0.2 0.1 0.5]

Table 7.11: Other variables

Variable	Value		Variable	Value
Kind of landscape	Dynamic		Divisions	4
Landscape	Igor		Venture leaders	6
Exhaust factor	[0.1 0.1 0.5]		Link memory	20
Mean patch increase	10		Forward setting	25
Std dev patch increase	5		Start target	50
Firm starting budget	50,000		Actual max?	True
Type of income	Delta fitness		Stop?	True
Firm reserves	1,000		Debug	False
Cost of investment	150		Weight divergence	0, 20, 50, 80

8 RESULTS AND DISCUSSION

Within this chapter the results of the experiments will be discussed after which the following sub-question can be answered *Which theoretical phenomena can be simulated with the constructed theories?* Each experiment has been defined in chapter 7. For all experiments box plots have been made in order to visualise the results. The data has been visualised with the help of box plots because of the large variance in the results. A box plot there can easily visualise the median and quartiles of the data set.

8.1 RESULTS

8.1.1 Context influences strategic action

The first experiment has been executed to test whether the context influences the strategic action or not (see section 7.2). According to the theory the simulation output under extreme strategic context should favour autonomous strategic action. While when focusing on the structural context there should be more induced strategic action. Before diving into the results, it is important to know that although the experiment has 100 repetitions, there still is a large spread to the results of this experiment. This is most likely due to the random positioning of the divisions and their venture leaders. Before processing the data, some filtering has been done. As each autonomous action is counted in the simulation the only interest is what the score is at the end of the simulation time of 320 ticks (80 years) or less if the simulation stopped prematurely. The graphs below have been based on the data of the last tick of each run. When the data has been filtered to only the data of the last ticks, the repetitions have been merged. For this experiment there is interest in the total number of autonomous action, therefore the self- and other-autonomous actions have been added together into the total autonomous action.

The results of the simulation show a large difference between the two contexts. Figure 8.1 shows a box plot of the total initiated autonomous actions for both strategic and structural context. It shows that a strategic context setting in the simulation will result in more autonomous induced actions. To be clear the total initiated autonomous variable represents both self-induced strategic action and other-induced strategic action.

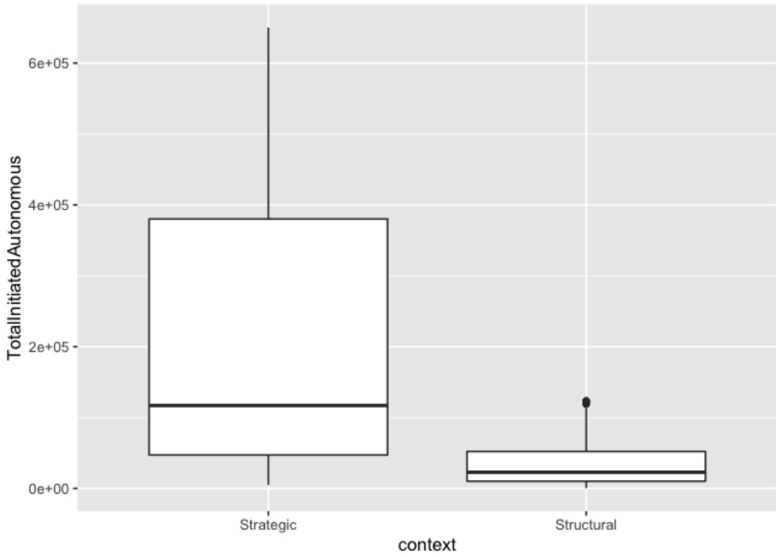

Figure 8.1: Total initiated autonomous initiatives per context

Comparison between the context and the total championed autonomous actions (figure 8.2) show that the strategic context setting results in a lot more championed strategic actions. The total championed autonomous actions represent the self-championed and other-championed strategic actions.

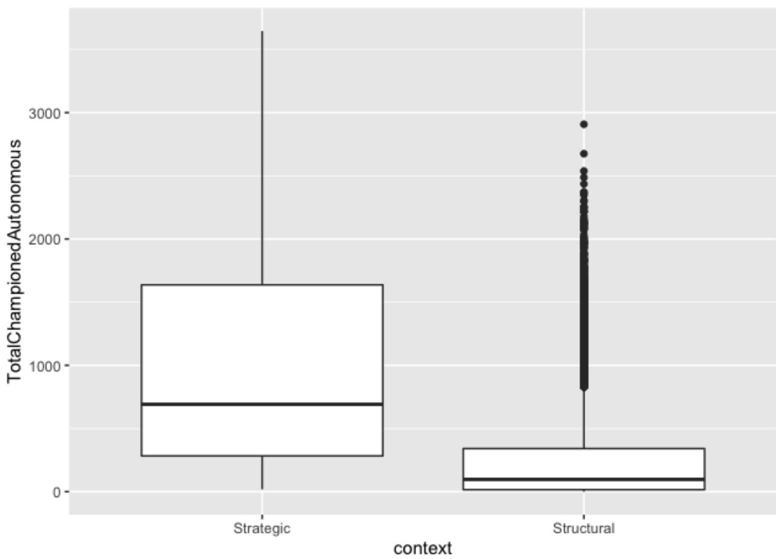

Figure 8.2: Total championed autonomous initiatives per context

Visual inspection of the total executed autonomous action (figure 8.3) shows a lot executed autonomous actions in the strategic context settings than the structural context setting. As can be seen, there is still quite some spreading in the results where the mean of the total executed autonomous action is around the 35 actions for the extreme strategic context case. Whereas the mean in the extreme structural context case is around 4 executed autonomous actions.

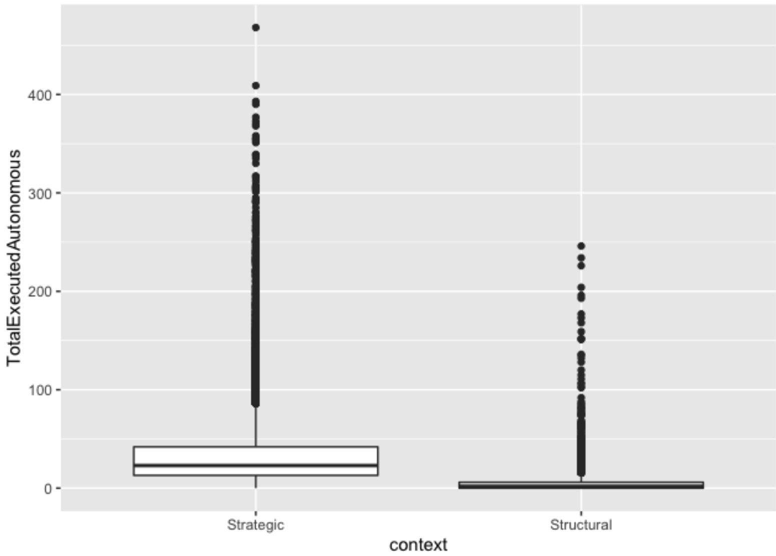

Figure 8.3: Total executed autonomous initiatives per context

As seen in the plots the strategic context results in more autonomous strategic action. This means that the agents in the agent-based model initiate, champion and execute a lot more autonomous strategic actions when the model settings are set to an extreme strategic context. For the extreme structural context the plots show that there still is some autonomous strategic action as a result of the simulation. This shows that even without a strict structural or strategic context both (autonomous and induced) strategic actions appear in the model.

To conclude this experiment, the hypothesis *A simulation setup which has full focus on the strategic context, would result in more autonomous strategic action when comparing this to a full focus on structural context.* can be accepted. The box plots show a clear difference between the two contexts. It even shows that under the extreme structural context settings the autonomous strategic actions still get initiated, championed and executed.

8.1.2 Context performance in a dynamic environment

The second experiment has been executed to test if the extreme strategic context case performs better in a dynamic environment when compared to the structural context case. The performance has been defined as the survival rate of the simulated organisation. There are two ways the simulation stops premature, the first one is going bankrupt. The simulated organisation has no resources left to invest and thus the simulation cannot proceed. The second reason to stop the simulation is when the venture leaders cannot find another suitable investment option. They thus have finished learning about their environment and do not succeed in finding a better investment solution.

In figure 8.4, a plot of the density per last tick of a run is shown. This plot is called a "violin" plot and shows the survival rate per context. The plot shows that with an extreme structural setting there is a much larger amount of simulations that stop before they reach 50 ticks, when compared to the extreme strategic context settings. It also shows that there are much more simulated runs which match the 320 ticks in the strategic context settings, this is the maximum run time of the simulation.

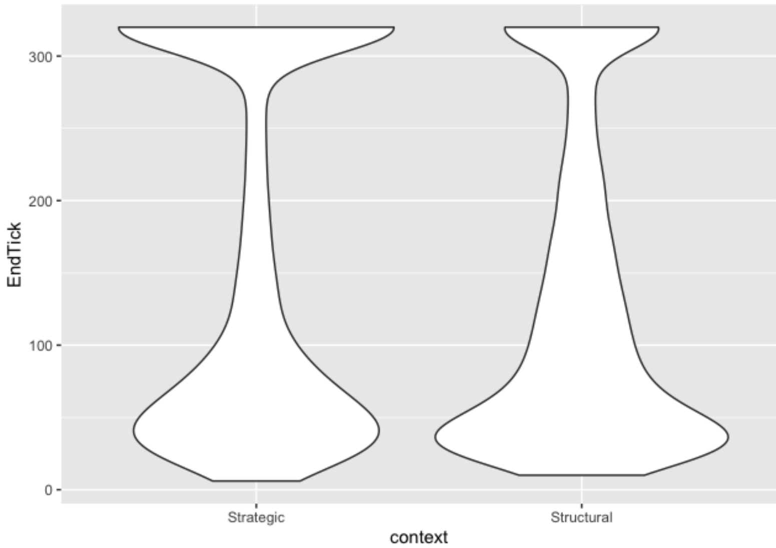

Figure 8.4: Survival time per context in ticks

To conclude this experiment, the hypothesis *Within the model the more strategic context will perform better in a dynamic environment than a more structural context.* can be accepted. More organisations survive with the extreme strategic context case in a dynamic landscape than with an extreme structural context. Which is shown by the number of simulations which had to be stopped due to the simulation time limit versus the number of simulations that stopped because the organisation went bankrupt or had no more investment options available. This means that within the simulations the organisations that focus on organisational learning can handle environmental changes better than organisations that focus on control.

8.1.3 The effect of opportunity space

The third experiment has been executed to test the effect of the opportunity space. An increase in the opportunity space should increase the amount of autonomous strategic actions. This experiment has an increase of the variable viewing range. The viewing range is the formal translation of the conceptualised opportunity space. Giving the venture leaders more room to look around should increase the opportunities they could initiate.

In the plot of figure 8.5 there is a clear increase in total initiated autonomous actions for increasing viewing range. This result is as expected as the increase in viewing range increases the number of opportunities a venture leader can inspect. When a venture leader initiates an opportunity he initiates all the opportunities which are visible to him. The more visible patches therefore results in more initiated autonomous actions. The result of this plot thus confirms the implementation of the concept.

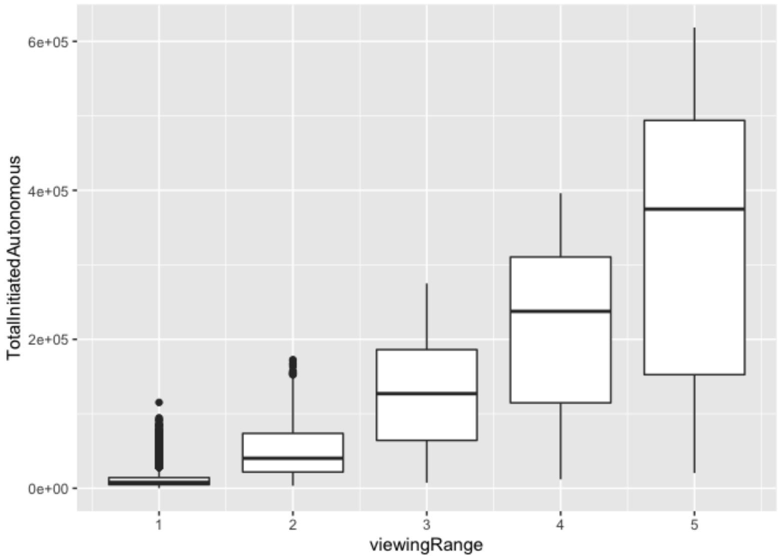

Figure 8.5: Total initiated autonomous initiatives per viewing range

In theory both initiated autonomous initiatives should be similar for both contexts. Within figure 8.6, there is a very clear difference between the strategic and structural context. The structural context has a larger amount of initiated autonomous initiatives for the viewing range setting of value 4 and 5. This could be explained by the stricter set target upper-bound, which result in quicker intervention of the division managers. This intervention for getting above the target upper-bound, results in the venture leaders having to stand still. This intervention causes the venture leaders to change their plans more often, resulting in the higher initiated autonomous initiatives.

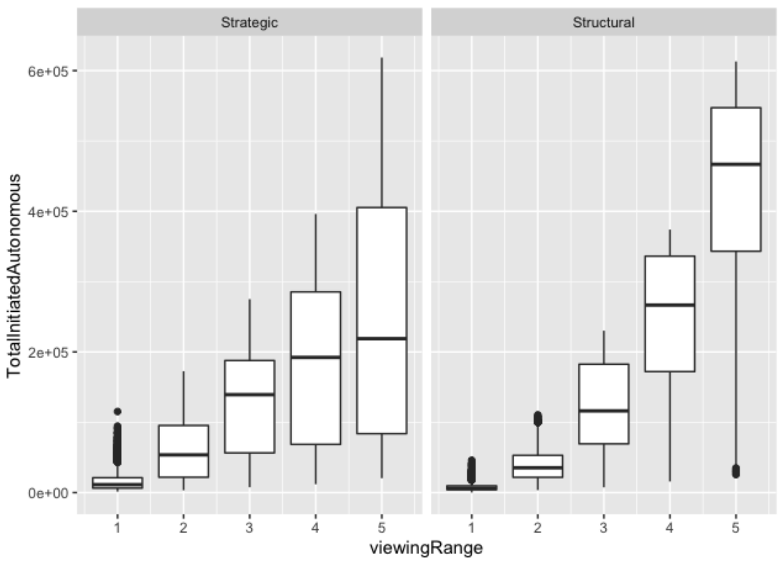

Figure 8.6: Total initiated autonomous initiatives per viewing range per context

The total championed autonomous projects show a large difference between each step of the viewing range, for both the strategic and structural context (see figure 8.7. While for the structural context a clear increase is shown, the strategic context does not show a very clear increase. In fact, the average of the championed autonomous projects for settings 3 and 5 are similar within the strategic context. The spread of the setting to 5 is much larger. A possible cause of this effect is that the agents are able to explore the landscape a lot quicker and thus end the run prematurely.

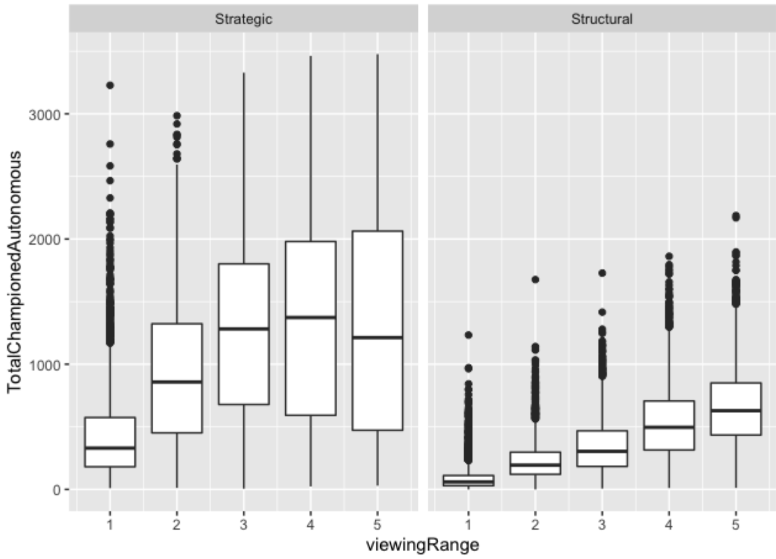

Figure 8.7: Total championed autonomous initiatives per viewing range per context

For the executed autonomous projects for both contexts there is an increase visible (figure 8.8). But for the strategic context the total executed autonomous projects increase is very clearly visible. The increase in the strategic context is much larger, but this fits with the fact that the division manager has to agree on executing autonomous initiatives. The division manager has to judge each initiative, when more initiatives are championed more would be executed in a strategic context.

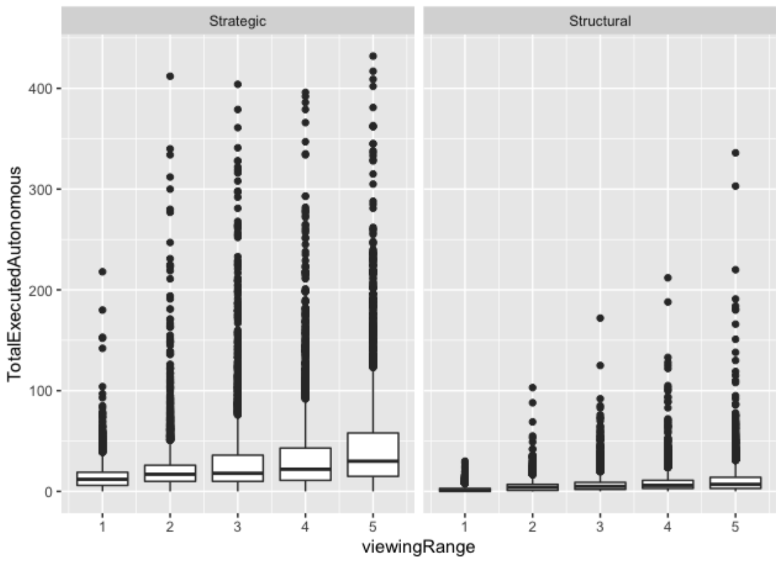

Figure 8.8: Total executed autonomous initiatives per viewing range per context

To conclude this experiment, the hypothesis *An increase in opportunity space within the agent-based model, would increase the amount of autonomous actions within the simulated organisation.* can be accepted. The increase in viewing range shows that the agents have more options to review. Therefore the agents get to know the landscape much better and can decide to take autonomous actions when the situation calls for that.

8.1.4 The effect of communication

The fourth experiment has been executed to test the effect of communication. An increase in communication range should increase the organisational learning and thus the agent's knowledge of the landscape. For this experiment when the communication range is increased, the result to look for is an increase in autonomous strategic actions.

In figure 8.9 there are three box plots which show the total autonomous action per communication range setting. The three figures are quite small and presented in appendix D. A visual inspection reveals that for each communication range setting the values are the same. A test on differences between the means (appendix E, table E.1), revealed that there is no significant increase for the **total** autonomous actions. This means that the **total** of **self-** and **other-** autonomous strategic actions do not increase significant with an increasing communication range.

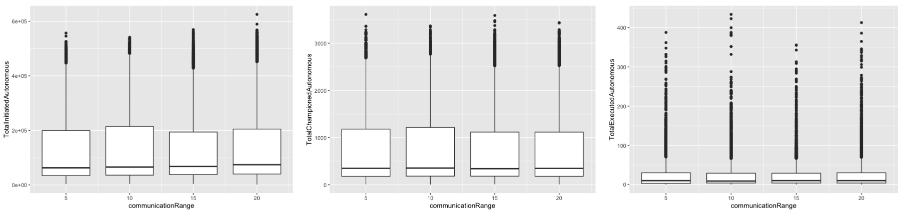

Figure 8.9: From left to right: Initiated (a), Championed (b), Executed (c) autonomous initiatives per communication range (larger files in chapter D)

As visible in figure 8.10, the differences are very small, while this time the difference between the contexts is specified. The expectation was that the communication range would increase the autonomous action of the venture leaders, it does not increase the total autonomous action. The communication range does not increase the total autonomous strategic actions. But hypothesis 4 can not be rejected just yet. The reason why this effect is not visible is because of the total amount of autonomous strategic actions which get initiated while the model runs.

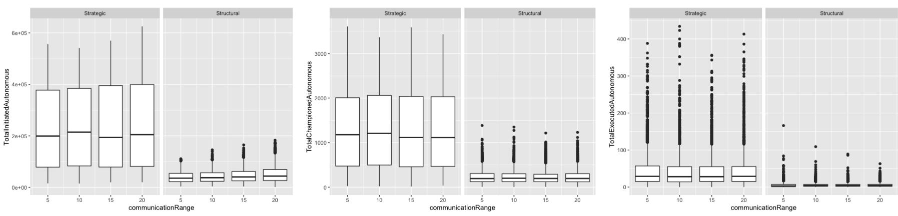

Figure 8.10: From left to right: Initiated (a), Championed (b), Executed (c) autonomous initiatives per communication range per context (larger files in chapter D)

Figure 8.11, shows that there is a clear increase in **other** initiated autonomous strategic actions. These show that the communication range does have an influence on the other autonomous strategic actions. In the total initiated autonomous actions it is really difficult to see the difference in autonomous actions. The difficulty of noticing the increase is due to the large amount of **self** autonomous actions. But when only looking at the other initiated autonomous actions (figure 8.11) there is a clear difference visible. Therefore it can be concluded that increasing the communication range increases the amount of initiated autonomous actions.

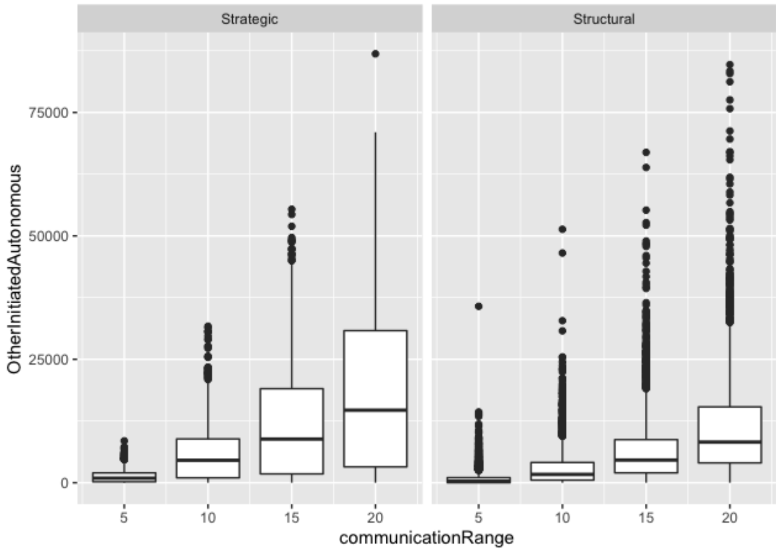

Figure 8.11: Other initiated autonomous initiatives per communication range per context

In figure 8.12 there again is no visual difference between the **other** championed and executed autonomous initiatives per communication range per context. The statistical test (appendix E, table E.1) reveals that there is a significant difference in **other** executed autonomous actions. For both the strategic and structural context there is a significant increase in other executed autonomous actions.

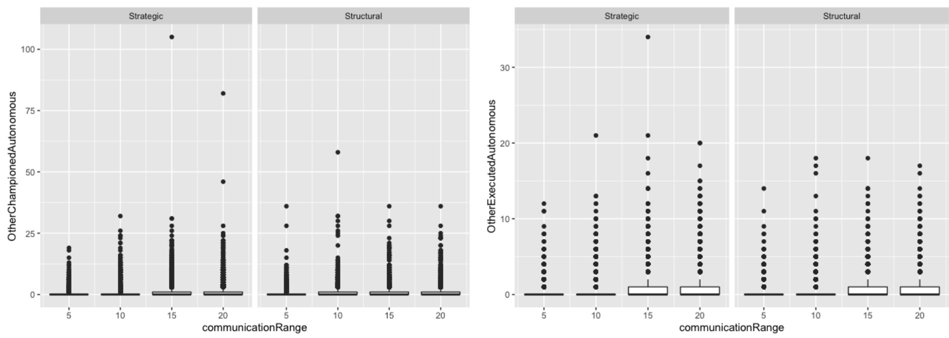

Figure 8.12: From left to right: Championed (a), Executed (b) autonomous initiatives per communication range per context (larger files in chapter D)

To conclude this experiment, the hypothesis *An increase of the communication range will increase the amount of autonomous strategic actions.* needs to be rejected. The increase in total autonomous strategic actions is not significant. Therefore the hypothesis has to be rejected. Although this hypothesis is rejected, the **other** autonomous actions reveal that the communication within the simulation works. This experiment has shown that the communication is of little influence in the current implemented model.

8.1.5 The effect of diversity

The fifth and final experiment of this thesis has been executed to test the effect of diversity within the organisation. According to the theory [Page, 2017] a diverse team has different perspectives on their environment and therefore should result in more autonomous strategic action. A diverse team is simulated with the help of the variable weight divergence. The larger the value of the variable, the larger the difference in knowledge of the agents. The knowledge is represented by the decision-making variables which the venture leaders have.

The effect of the heterogeneous division managers and venture leaders is visible in figure 8.13. With the weight divergence setting set to 0 it shows the same outcome of the first experiment. With the increase in diversity, it is clearly visible for the strategic context there is an increase and for the structural context a decrease. Something else that is notable, is that the spread of the total initiated autonomous actions becomes smaller when there is more diversity within the divisions. The increase in the strategic context means that within the strategic context there are more venture leaders which decide to take autonomous induced actions. This effect can be explained by the fact that the agents have a different perception on the landscape. The autonomous actions are no longer dependent on the location in the environment but on the preference of the venture leaders.

A possible explanation for the significant decline (appendix E, table E.2) in initiated autonomous actions for the structural context would be the settings of the venture leader preference for the structural context. Within the structural context the venture leaders are already more conservative with their resources. The way diversity has been implemented in the model probably causes the venture leaders to become even more conservative.

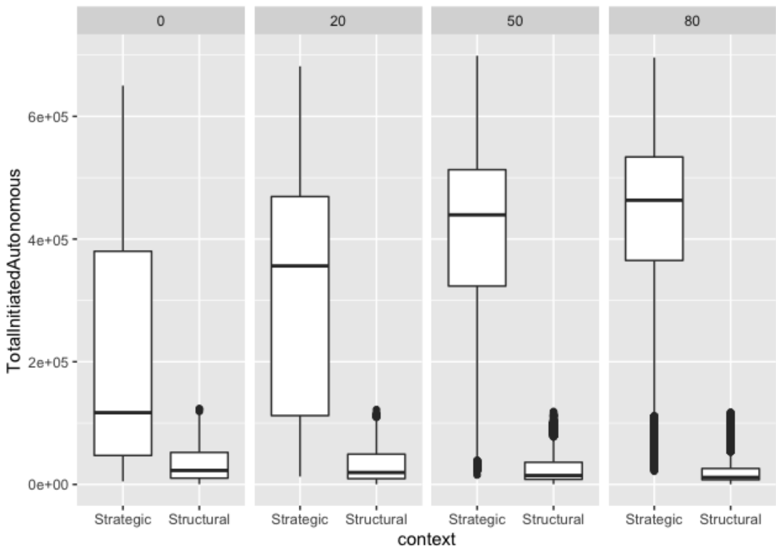

Figure 8.13: Initiated autonomous action per context with heterogeneous agents

In figure 8.14, the championed autonomous action is visualised for the difference in heterogeneity. The venture leaders champion less autonomous actions with an increasing diversity. There is an increase in championed autonomous actions between no diversity and diversity. But as the level of diversity increases the championed autonomous actions decline. This means that within the simulation, if there is an increase in diversity the championed autonomous action increases. This could be the result of the implementation of the diversity within the model. Another possibility would be that there is a tipping point within diversity, if there is too much diversity the autonomous action would decline. For the structural context there is a clear and significant decrease visible. This again might have to be the result of the modelling decisions taken while implementing the diversity of the agents.

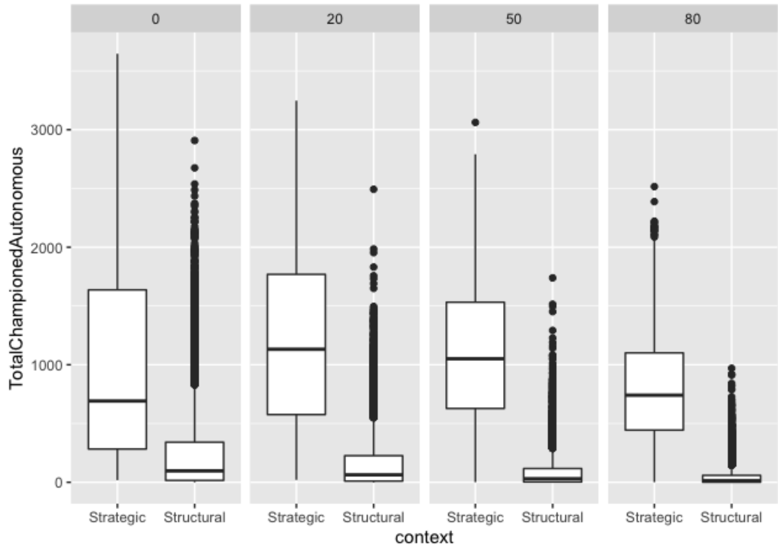

Figure 8.14: Championed autonomous action per context with heterogeneous agents

In figure 8.15, the executed autonomous actions have been visualised compared to the divergence in heterogeneity. The decision preferences for of the division managers seem to have less preference for autonomous actions as the heterogeneity grows. For the strategic context it means that the division managers have less preference for autonomous actions as the diversity grows. As for the structural context there also is a significant (appendix E, table E.2) decrease in total executed autonomous actions for an increase in diversity.

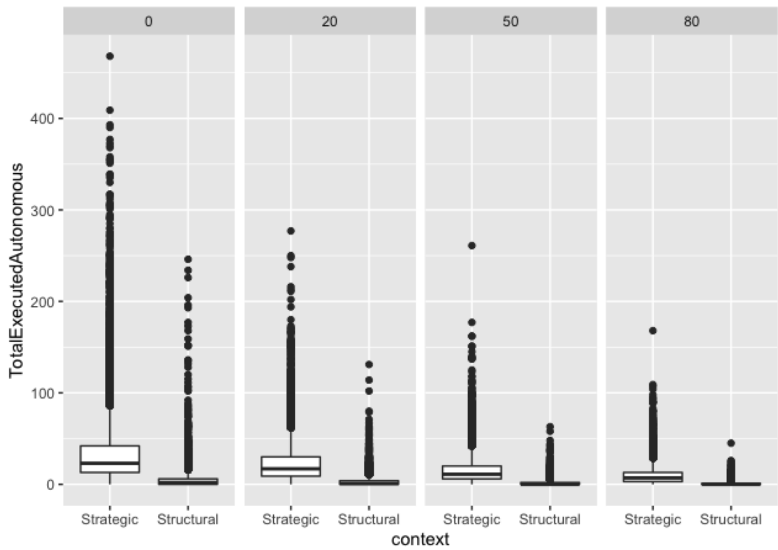

Figure 8.15: Executed autonomous action per context with heterogeneous agents

To conclude this experiment, the hypothesis *Diversity between the agents in the defined agent-based model would increase the amount of autonomous strategic action* needs to be rejected. For both the structural and strategic contexts there are less autonomous strategic actions executed as the diversity grows. The reason for the decrease is likely to lie in the modelling decisions taken while implementing the diversity functionality. Another conclusion that can be derived from this experiment is that the spread within the experiment decreases due to the added diversity.

8.2 DISCUSSION

This section will discuss the results of the experiments. What does this mean for the developed model, the literature and possible societal relevance. Over all the experiments revealed that the model is functioning, but some mechanisms are not functioning as expected. The limitations will be discussed at the end of this chapter.

8.2.1 Discussing the results

THE CONTEXT EXPECTED OUTPUT of the first experiment was that the extreme structural and strategic context settings are delivering the expected results. The extreme settings reveal that the autonomous and strategic measurements work within the constructed model. The agents thus either follow the corporate strategies or decide that they have a better idea. This outcome is a result of all the theories merged within the agent-based model. Being able to simulate this process and having the expected outcome as a result is a success. It also is very interesting for a lot of organisations and scholars researching the resource allocation process. With the help of a model such as the developed agent-based model a lot of efficiency improvement could be achieved. For the scholars this outcome is a beginning of a new research method that facilitates research on the relationships within the resource allocation process. The scholars will now be enabled to conduct a lot of experiments on a hypothetical organisation and possibly discover the causal relationships within the resource allocation process.

FINE-TUNING STRATEGY ACCORDING TO THE ENVIRONMENT is a possibility which resulted out of the second experiment. The model revealed that operating in a dynamic environment with a more strategic context is the better approach. This is in line with the theory of Burgelman [2002]. There are two aspects of this result, the first being that the model confirms the theory; the formulated dynamic function of the agent-based model in combination with the formulated context is able to reproduce the effect which Burgelman discovered in his study on the Intel case. Secondly with the help of this model, future researchers could define what combination of contexts would have more success within a certain organisational environment. Knowing the right balance between the structural and strategic context could result in efficient allocation of resources, stimulating innovation and resulting in more efficient development. Where the efficiency increase in innovation contributes to solving a lot of current world problems.

DEGREE OF FREEDOM revealed that the effect of being able to view more opportunities resulted in a lot more analysed opportunities which lie outside the corporate strategy. The analysed opportunities caused a lot more autonomous actions to be committed, and even an increase in autonomous actions being executed. This result is in line with the expectations according to the literature. The result which can be abstracted from this behaviour is that the modelling decisions are according to the expectations and that the current formulation agrees with the literature. But the simulation takes a lot more computation time when increasing the opportunity space. This is a logical result as the agents have to analyse a lot more potential opportunities. But this thus means that in real life, when an organisation increases their opportunity space, it means that the venture teams also need more computation time. So a large opportunity space, which translates to opportunity seeking further from their core business, could either result in less accurate analysis or consuming a lot more time. A possible purpose of this model could be the search for the optimal proportion of opportunity space. This purpose could increase efficiency within organisations and be specific for the organisations situation. For scholars it would be interesting to find out if there would be a minimum or maximum degree of freedom in opportunity seeking within organisations. The attention to the degree of freedom could be related to the other mechanisms to try to increase or reduce the level of autonomous strategic actions.

COMMUNICATION RESULT IS NOT AS EXPECTED , the result of increasing communication did not result in the increase as expected. The experiment did prove that the agents communicate with each other as the other- autonomous strategic actions revealed. Not only did it reveal that they communicate with each other, but also that they use the knowledge obtained from the communication. There are two possible causes of the result not meeting expectations. The first resulting in modelling decisions, the way communication has been implemented in the model could cause the insignificant increase in autonomous actions. The communication is now only checked within the special action strategy. This has been implemented specifically as in real life venture teams would not always discuss their colleagues. A second possibility would be that communication in real life would result in the same outcome as the model outcome. It could very well be that in reality, the autonomous strategic actions which are a result of communication would be corresponding outcome with the model. Either way it is very useful to know that the result of communication contributes to the organisational learning of the environment. When the reasoning of the insignificant contribution to autonomous strategic actions by the communication is clear it is a very useful working mechanism for future causal relationship research within the resource allocation process model.

EFFECT OF DIVERSITY NOT AS EXPECTED , the effect of diversity has not been according to the expectations. Diversity does show an increase in autonomous actions for the initiated autonomous actions. Also for the committed autonomous actions, but here the effect seems to fade as the diversity increases. For the executed autonomous actions the effect clearly does not match the expected outcome, the executed autonomous strategic actions become a lot less.

This is very likely the result of a modelling decision of the decision weight variables. With the current implementation the division managers and venture leaders start with their (by the modeller) predefined preferences and a random value, based on the weight divergence this gets subtracted from that predefined value. The modelling decision has been made as the decision variables need to all sum op to a total of 1. Therefore it is a difficult way of creating diversity, where some have more preference than set and others have less. Although the current implementation thus creates diversity, the diversity did work for the operating levels of the simulation as it showed a lot more initiated and championed autonomous actions. But for the division management it did not work.

8.2.2 General discussion

The results of the experiments have been discussed and clarify the phenomena that can be simulated with the agent-based model. The developed model has been designed in order to improve understanding of the resource allocation process. The model has been defined in such detail that it provides explanation of all sub-processes step by step, while keeping it generic. The step by step explanation can help scholars and organisations understand the mechanisms in the resource allocation process. Each of these mechanisms can be controlled within the model. The output of the mechanisms is measured through the strategic actions for each stage of the process. With the ability to track the strategic actions for each stage of the process, analyses can be performed on how different inputs lead to different outputs. Relationships between the mechanisms can be defined and the result of that analysis can be used to improve the process. The model as-is can not be used for specific organisations, but the definitions in this model will support scholars in defining models that can be used for specific organisations.

The model could also be used to define the boundaries of the resource allocation process. Experiments could reveal what minimum levels of control are required to have a functioning organisation. This could be researched for several types of environments. Knowing these limits will help organisations determine how they can setup their organisations such that they still function but also spend a great deal on autonomous strategic actions.

8.2.3 Modelling decisions

In the previous sections the results of the experiments and the general use of the model has been discussed. This section will discuss some modelling decisions which require attention in future developments or future work.

BANKRUPTCY WITHIN THE MODEL is an occurring event. While playing with the model and even within the experiments the model showed that there are many cases that a simulation run does not make it until the end. This means that the simulated organisation goes bankrupt within the environment they are in. This could be absolutely possible in the real world, just having bad luck or not taking the right decisions. Within the current setup model the bankruptcy is likely to be linked to the random coordinates the agents start their simulation. It would be useful to exactly know how what leads a simulation to bankruptcy and what time it needs to survive to reach the maximum time limit. By knowing this the modeller would be able to know if a simulated organisation would be in the category "start-up" or a "mature" business.

DECISION-MAKING VARIABLES DIVISION MANAGERS for this research have been set according to own developed insights. As a result of working with the resource allocation literature and understanding of structural and strategic context determination of the preference for extremes of these contexts could be defined. But this still is a matter of perception and rely on the modeller. Therefore it would be useful to have a group of experts fill in a survey, or even fill in the best-worst tool as used to define the weights for the decision-making variables. An average of this group of experts could then be used for future research. Then the decision-making would not rely on just the perception of one person. If the developed model would at one point in time be used for organisational specific research, the responsible managers should all fill in a survey in order to get to know what the decisions in the organisation are based on. The preferences of the division managers can be influenced but it would support the research if (an average) of preferences would be known beforehand.

THE LANDSCAPE used within this model has been constructed to prove the concept of a dynamic rugged landscape. For future experiments it would be required to define a rugged landscape which would suit the purpose of the type of organisation which would be researched. The settings do not stop with the design of the landscape, also the other environmental settings would have to be matched with the landscape. e.g. the Exhaust factor, Cost of investment and even the resources obtained from a specific investment. These variables should match the corresponding landscape and could be fully adjusted to the situation without any changes to the constructed model.

ORGANISATIONAL LEARNING could be further developed such that that the agents learn from the division manager what the settings of the division manager decision weights are. This corresponds with the fact that the agents learn if their request for resources are typically granted, and the way they are measured and compensated [Bower et al., 2005]. They should not be able to "read" this from their division manager but should be able to really learn this, maybe with the help of a learning mechanism as trial and error.

8.2.4 limitations

Within the results of the experiments there is a large spread in the measured outcome. Increasing the repetitions from 100 to a much larger number might decrease the spread in the results. Increasing the repetitions of each experiment will increase the computation time of each experiment. Fortunately the spread did not matter for proving or disproving the hypotheses, and thus had no effect for the outcome of the research.

A factorial analysis has not been conducted on the developed model. Therefore there is unknown what specific variables influence the outcome of the simulation. The Latin Hypercube Sampling method would be a solution to effectively analyse the input variables of the model. With the results of a factorial analysis the modeller would know if there are critical tipping points or even critical variables implemented in the model. For the current research a factor analysis is not absolutely necessary. The objective of this research was to develop an agent-based model of the resource allocation process. There are two extreme settings which have been set according to theoretical perceptions. For now, the assumptions used for the contexts delivered the expected outcome, and with those contexts some phenomena could be simulated. It was not known if the model would work and *could* prove some of the phenomena. So therefore, a factorial analysis was not deemed critical for this research.

The last limitation is that this research did not test the model on a specific real life case. Where existing literature mainly focused on specific cases, this thesis only focused on a generic model. This thus is a limitation as a test on functioning on a real world case would prove that it really is usable. The reason that this has not been tested is that it simply is not yet possible. Before testing the model on a real life case some additional research is required. A dynamic landscape must be developed to mimic the environment of the source case, with that the specific environmental settings like Exhaust factor and Cost of investment would have to be defined.

9 CONCLUSIONS AND FUTURE WORK

In this chapter the result of the entire research will be concluded. The resource allocation process of Bower and Gilbert [2005] has been used as a starting point and has been the leading model for the entire thesis. The most important parts of the resource allocation process model by Bower and Gilbert [2005] will be briefly discussed after which a general overview of the model conceptualisation will be discussed. In the end the results of the experiments will be discussed, which have been conducted to test the functionality and limits of the agent-based model.

9.1 ANSWERING THE SUB-QUESTIONS

Before the main research question can be answered in section 9.2, the sub-questions will be answered. The research questions have been introduced in chapter 2.

1) What mechanisms define the structural and strategic context of the resource allocation process in a way that they are suitable for conceptualisation?

The evolutionary framework of Burgelman [2002] defines how the structural and strategic context influence the organisations corporate strategy through strategic actions. There are two kinds of strategic actions which happen in the resource allocation process. **Autonomous strategic action** and **induced strategic action**. Autonomous strategic action is strategic action that does not follow the defined corporate strategy. Induced strategic action is strategic action that does follow the defined corporate strategy. In chapter 4 there is a discussion on when each kind of strategic action is useful. The core of the evolutionary framework is that strategic context determination will cause an increase of autonomous strategic actions, while structural context determination will result in an increase of induced strategic action.

As discussed in chapter 4, **strategic context determination** is of use when the focus within the organisation needs to shift towards a strategic mindset. With the strategic mindset the organisation focuses on understanding of their environment and organisational learning. This happens through less focus on targets, facilitating communication and opening the opportunities (e.g. allowing employees to invest time into opportunity seeking which are further from the core business). **Structural context determination** is of use when the focus within the organisation needs to lie on efficient execution of the defined corporate strategy. This happens through a focus on targets, a focus on core business, reducing distraction of employees (e.g. communication) and changing the mindset of employees to an efficient execution. The contexts thus can be defined through increasing and releasing control, restricting and encouraging communication, and changes within the organisations mindset.

2) What conceptualisation describes the resource allocation process suitable for model implementation?

The conceptualisation proposed in chapter 5 describes the resource allocation process in a way that is suitable for model implementation. In combination with the formalisation (chapter 6) resulted in an implementation in agent-based modelling software. The implementation provided feedback to the conceptualisation and formalisation which resulted in adaptation of these chapters. The resource allocation process can be conceptualised through definition of three agents: a corporate manager, division managers, and venture leaders. These agents interact while executing the resource allocation processes. They execute these processes within an environment which allows them to search for investment opportunities, provides feedback and be dynamic. Which resulted into a formalisation with a rugged fitness landscape which provides feedback to three kind of agents: a corporate manager, divisional managers, and venture leaders. The venture leaders trek through the fitness landscape by interacting with their colleagues and superiors. Each time they change their location they execute an investment, which costs the organisation resources. The executed investments either provide or cost the organisation resources. How much resources is depending on the fitness landscape.

3) Which theoretical phenomena can be simulated with the constructed theories?

In chapter 8, the results of the experiments tested the phenomena which the simulation could handle. Those are: the evolutionary frame work (context related strategic action), context performance in a complex environment, the effect of opportunity space, organisational learning through communication, and the effect of diversity.

The phenomenon of the evolutionary framework [Burgelman, 2002] has been accepted as a result of the experiment. To validate this, the model was tested with extreme settings of a strategic and structural context, the model outcome satisfies the expected outcome based on the theory. The model also satisfies the contextual performance in a dynamic environment. The phenomenon as defined by Burgelman [2002] stated that the strategic context is of importance within a complex environment. Within a complex environment the corporate management is not sure about their strategy. A simulation revealed that within a conceptualised dynamic landscape the strategic context setting performed a lot better than the structural context setting.

The model as build is unable to capture the phenomena of communication and diversity. The phenomenon of communication increasing the amount of autonomous strategic actions could not be reproduced. The defined experiment was not able to reveal the effect of an increase in communication leading to an increase in autonomous strategic actions. The effect of communication could not be captured as the difference is not significant on the total autonomous strategic actions. The second phenomenon which cannot be simulated with the constructed agent-based model is the effect of diversity within an organisation. An increase in diversity should result in more creativity, which leads to more strategic actions outside of the defined strategy results (autonomous strategic action).

9.2 ANSWERING THE MAIN RESEARCH QUESTION

With the answers to the sub-questions, this thesis can be concluded by answering the main research question. The research question has been formulated in chapter 2, the question reads:

> **What generative theory formulates the resource allocation process from Bower and Gilbert in order to make it suitable for modelling?**

Within this research a functioning agent-based model has been designed, tested and discussed, and it can be concluded that the developed model is a formulation of the resource allocation process from Bower and Gilbert. The resource allocation process framework by Bower and Gilbert is a very useful model for managers to help them work within the resource allocation process. It helps the professionals who use the model to structure their thoughts and not forget about aspects of the allocation process. Bower and Gilbert did not include a lot of detail in their explanation of their framework, so that is what this thesis did. In order to create an agent-based model there had to be full understanding of what a detailed definition would look like. The core concepts of each sub-process from the model had to be defined after which it could eventually be implemented in an agent-based model. The result is a generic agent-based model that, with the help of input variables can simulate all kinds of organisations. Definition of this simulation model resulted in a generic tool to start specific research into the relationships within the resource allocation process. It is possible to research cases specific situations, where a specific organisation or type of organisation can be simulated and the effects of specific interventions can be investigated. The produced agent-based model within this thesis can be of great use to support such research, even though there are some improvements possible.

9.3 FUTURE WORK

This research has shown that an agent-based model can be defined for the resource allocation process model. The result is a functioning model which can be used for all kinds of research. A couple of limitations were already mentioned but there are also some other thoughts about future work.

9.3.1 Communication and Diversity

The phenomena related to communication and diversity did not show a significant increase in autonomous strategic actions. It would be recommended to research the specific reason why the model is unable to capture the effect of communication and diversity. This could be caused by the way these mechanisms have been implemented in the model. It could also be that the effect of communication does not have a significant difference through other modelling decisions. Nevertheless it would be really useful for further research to understand why these phenomena are not able to be reproduced with the defined model. This will further help with the understanding of the resource allocation process.

9.3.2 Factorial analysis

Before extending the current model, it would be recommended to conduct a factorial analysis on the current implementation of the agent-based model. This will test the effects of the variables on the outcome of the simulation. The factorial analysis might reveal some interesting things which could be improved while extending the current model.

9.3.3 Extending the current model

The landscape should be defined according to the environment of an organisation. For this thesis a conceptualised landscape has been used to test the functioning of the model. When using this model for future research, a more realistic landscape should be used. Therefore a recommendation would be to design a set of landscapes with corresponding environmental settings. With a set of designed landscapes several kinds of markets could be input for the simulation. Alternatively a tool that can generate a landscape based on something like a companies yearly report would also be useful.

There should also be a method developed to carefully setup all the variables from the implemented model. It will be a challenge to find out what settings would need to be used in order to test a real world case. Testing a real world case should prove the developed method for setting the input variables of the model.

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A SEQUENCE DIAGRAM

This appendix shows a detailed version of the sequence diagram in chapter 5.

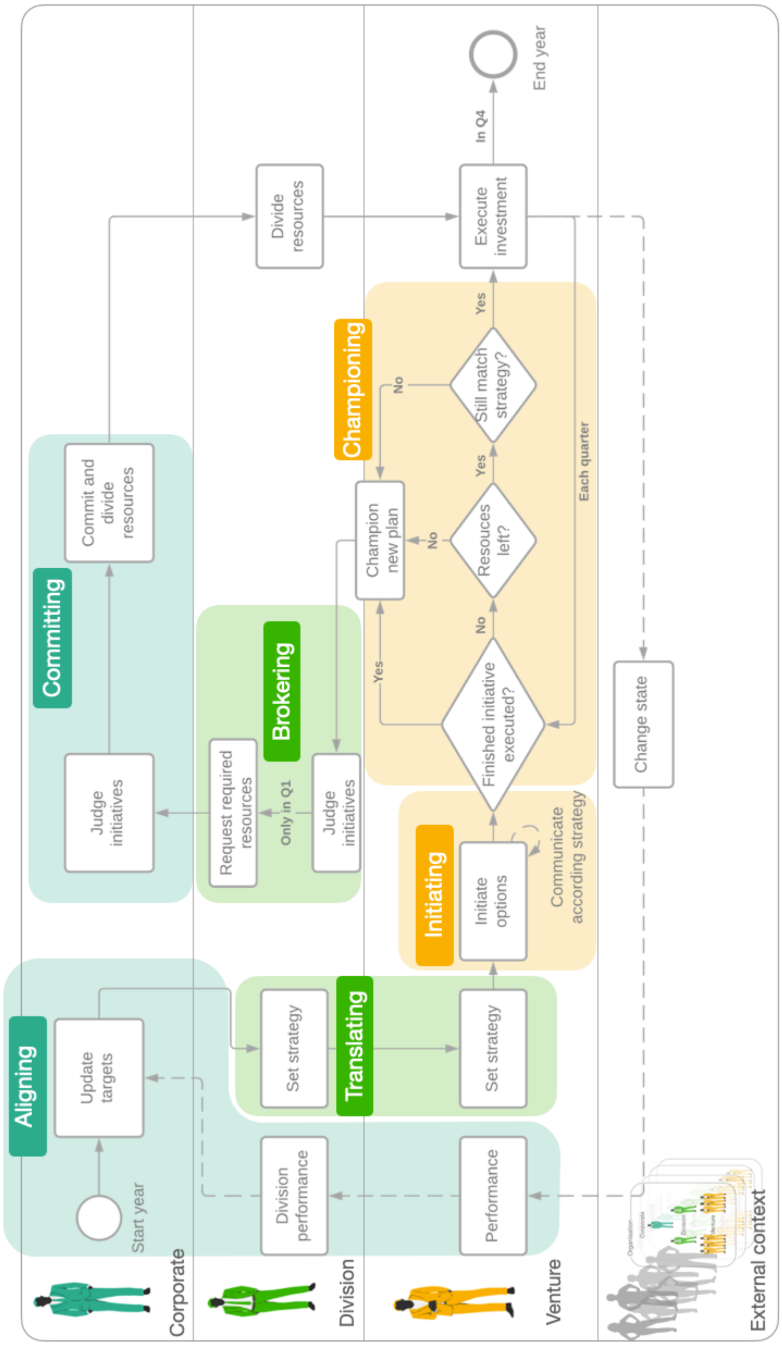

Figure A.1: Detailed sequence diagram of the resource allocation process

B FLOWCHARTS OF PROCEDURES

This chapter of the appendix describes the flowcharts which can be used to help understand the agent based model build for this thesis. The flowcharts visualise the implemented model. The terms used in the flow charts are similar to the terms used in the NetLogo code.

B.1 TRANSLATING PROCEDURE

This flowchart helps to visualise the formalisation of chapter 6.4. The translating process is ran by the division managers, they communicate which strategy their division is running to their venture leaders. They start by checking if the their target is still matching the firm average fitness. If the target is lower than the firm average fitness they set the target to the firm average fitness, otherwise they just proceed with the process. When the target has been checked they calculate the fitness of their division. The division managers check how they are performing. They can be in three kinds of fitness ranges see figure B.2. This is also visible in the flowchart of figure B.1. If the division is performing less than the lowerbound set by the modeller. The division manager checks if one of the venture leaders in his team is performing better than the set target. If this is the case the venture leaders get the order to set their strategy to *"Specific patch"*, if this is not the case they need to set their strategy to *"Walk straight"*.

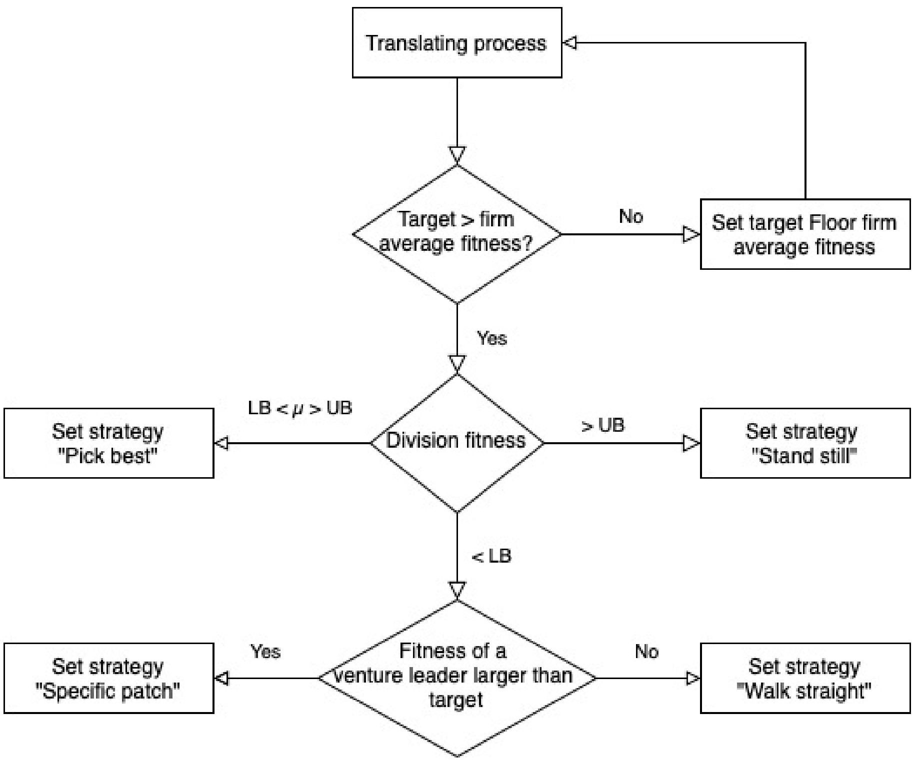

Figure B.1: Flowchart translating procedure

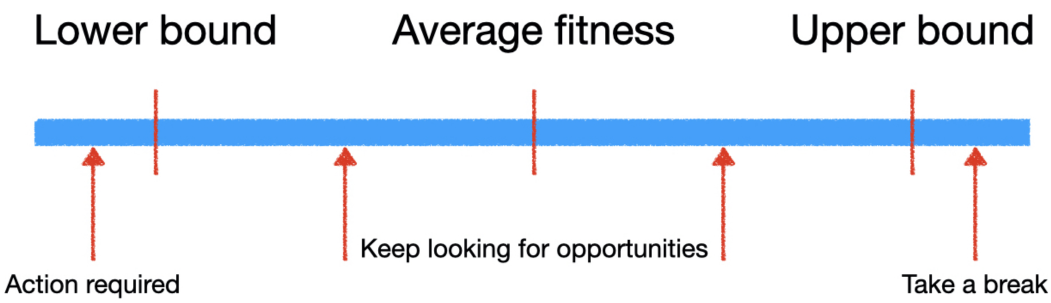

Figure B.2: Range of fitness levels from chapter 6.4

B.2 INITIATING PROCEDURE

In addition to the initiating procedure described in chapter 6.5 the calculate ratio procedure keeps on going until all ratio's are calculated. All ratios in combination with their fitness and corresponding patch coordinates are saved in the list *"ListWithRatios"*. The list *"ListWithRatios"* is then used to select the best option available, which is venture leader specific. So the *Initiating procedure* will be performed for all venture leaders. The weights used to calculate the ratios are set by the modeller, the normalisation factor *"Largest fitness value"* is filtered out of all possibilities the venture leader has. The normalisation factor *"ViewingRange"* has been set by the modeller.

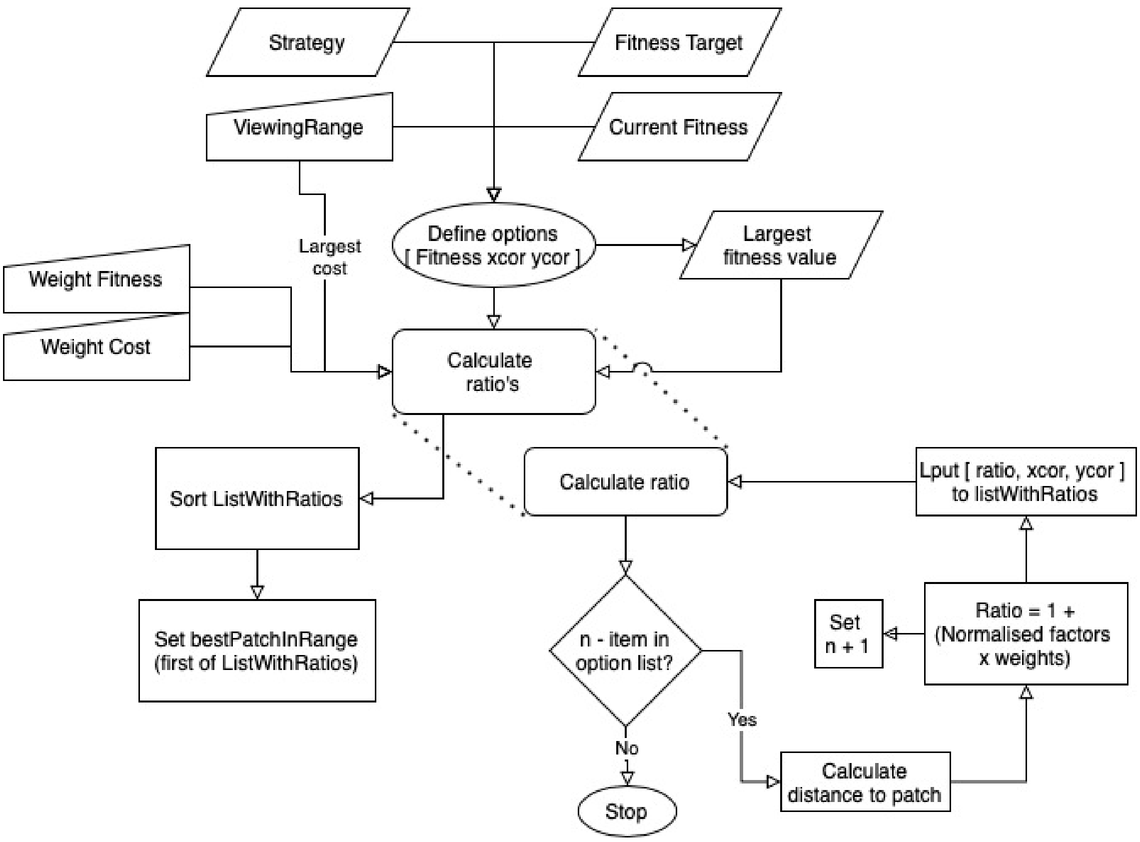

Figure B.3: Flowchart initiating procedure

B.3 CHAMPIONING PROCEDURE

The flowchart of figure B.4 starts at the strategy tile, from there the venture leaders have to pick which strategy they have received from their division manager. From there they follow the decisions and execute the required actions. If a venture leader needs to execute his strategy *"Specific action"* and their personal plan which they are still executing is better than their current fitness, they need to go on and execute their investments before changing their strategy.

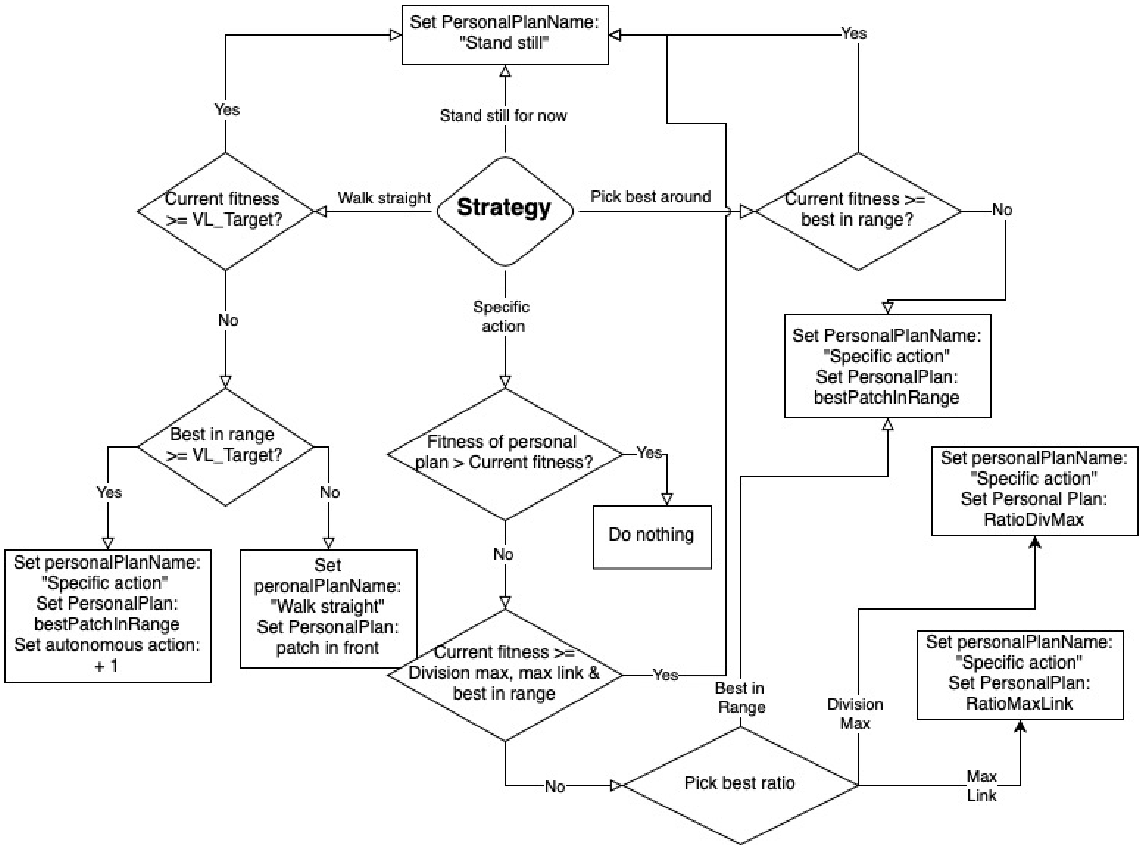

Figure B.4: Flowchart championing procedure

B.4 BROKERING PROCEDURE

The flowchart of the brokering procedure (see figure B.5) looks like a lot, but it mainly contains the variables required for the ratio calculations. The flowchart starts at the rounded tile *"Brokering: Division manager asks his division"*, there are three arrows departing from there, in some cases the uncertainty and the amount of investments to take need to be set. So these are just checks in certain cases. The ratio calculation formula is described in chapter 6.7.

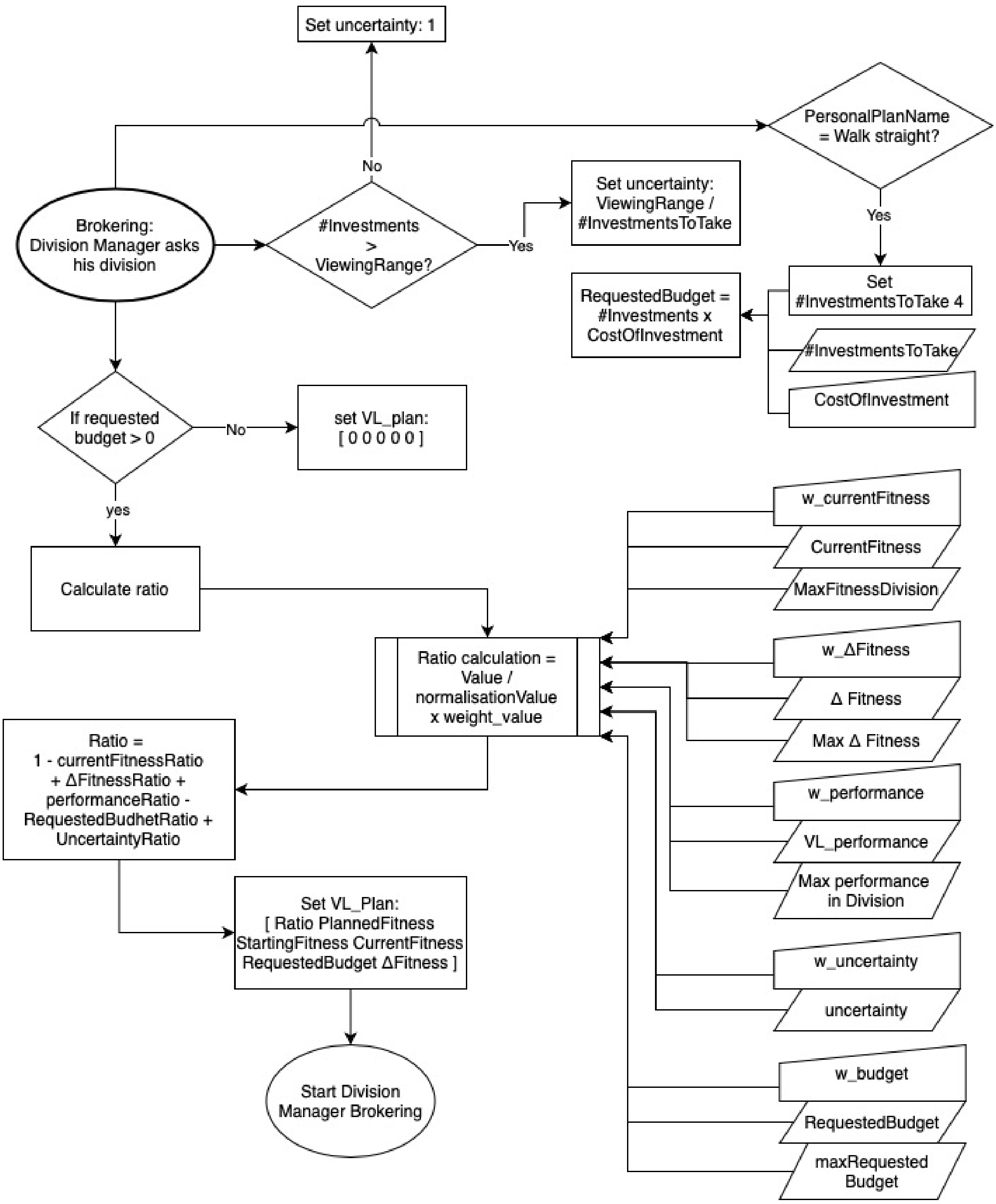

Figure B.5: Flowchart brokering procedure

In the previous flowchart (figure B.5) the brokering procedure where the division manager asks his division to perform actions has been visualised. In figure B.6 the actions the division managers have to take in order to request budget by the corporate management.

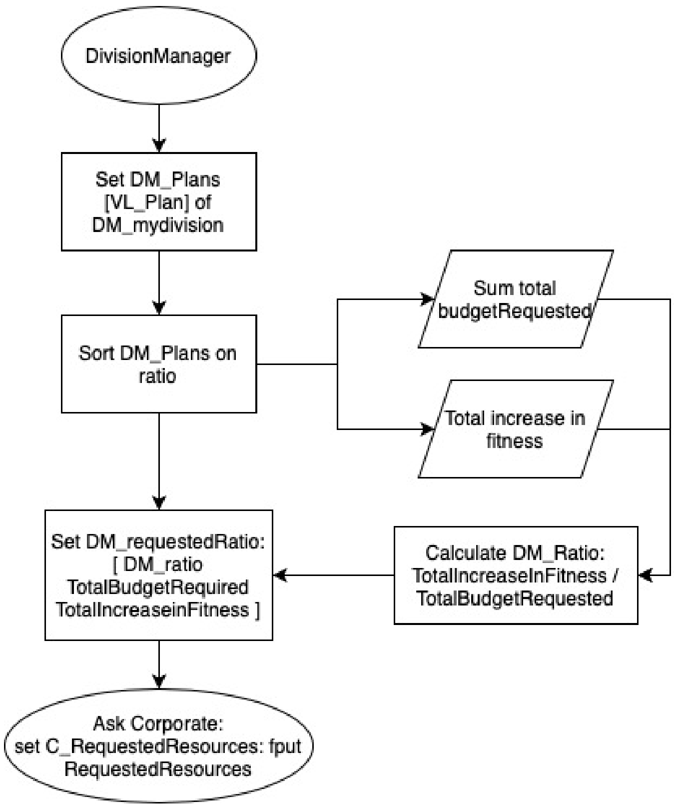

Figure B.6: Flowchart division manager brokering procedure

B.5 COMMITTING PROCEDURE

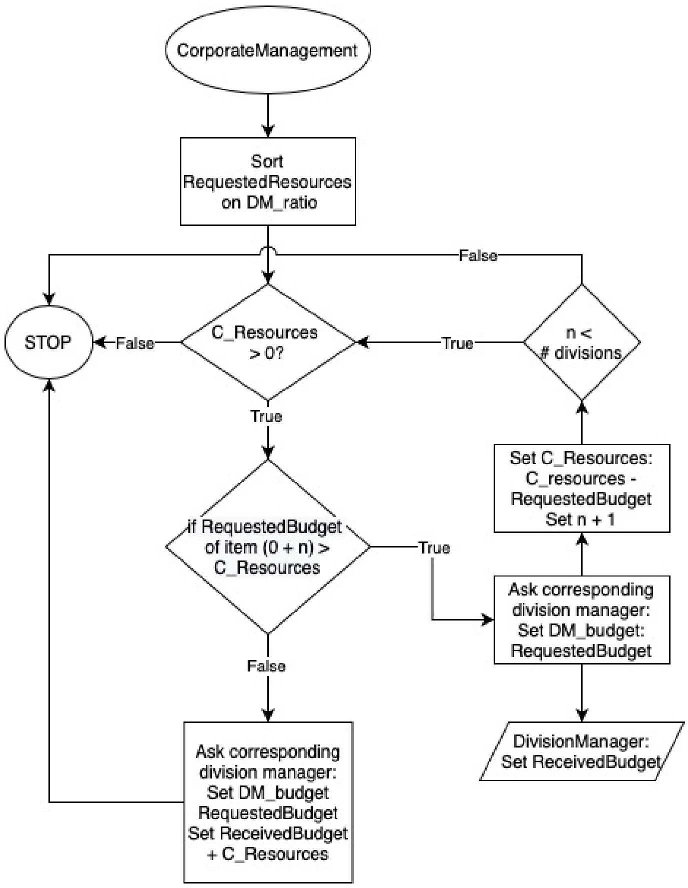

Figure B.7: Flowchart committing procedure

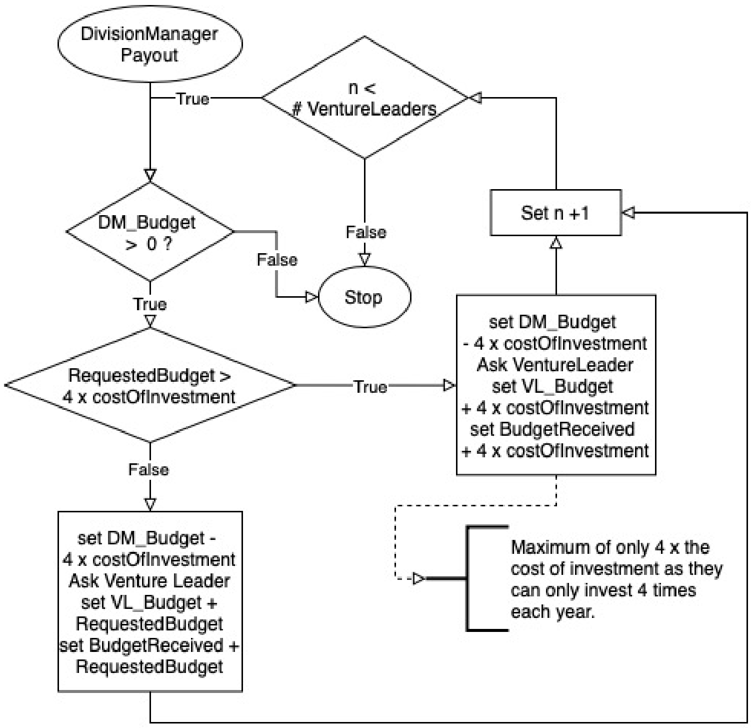

Figure B.8: Flowchart payout of resources

B.6 EXECUTE STRATEGY PROCEDURE

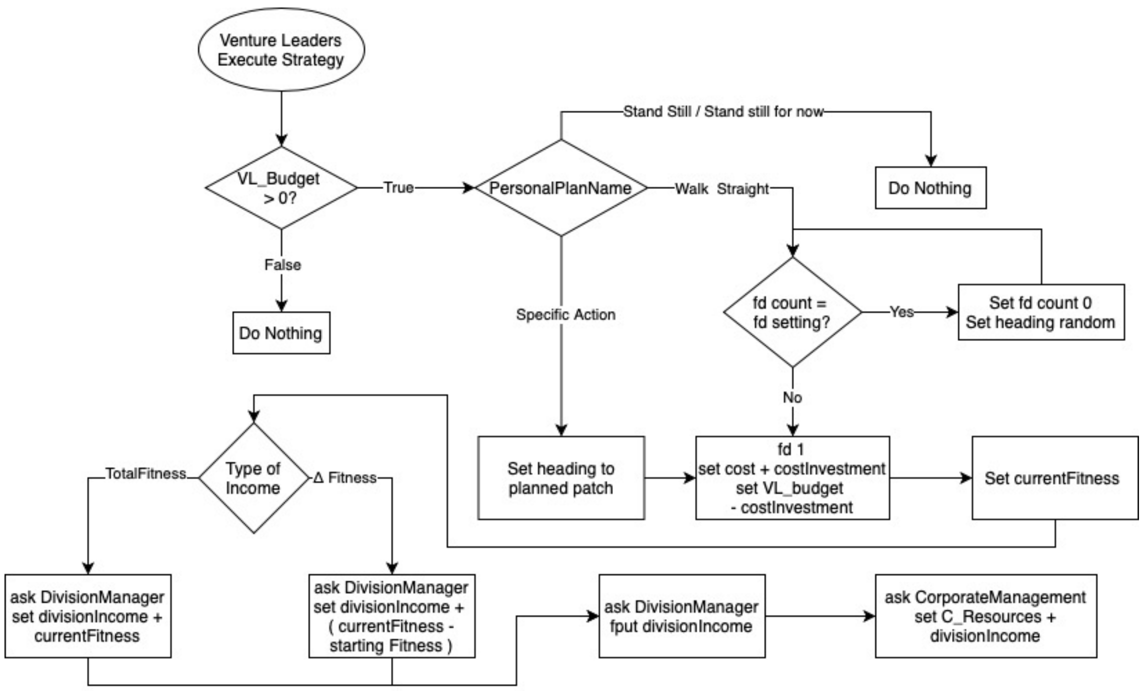

Figure B.9: Flowchart execute strategy procedure

C IMPLEMENTATION DECISIONS

C.1 IMPLEMENTATION OF THE USED RUGGED LANDSCAPE

The software used for current implementation (NetLogo) uses patches to divide the simulated world. The amount of patches can be set by the modeller and could be set according the required situation. Resulting in a world which is represented by $n * n$ patches. The patches itself are x and y coordinates which are represented by little squares, where the size of the squares is again set by the modeller. The patches could interact with their surrounding but are not able to move to other coordinates [Wilensky, 1999]. Given the fact that the modeller could very easily change the size and shape of the simulated world, the implementation of a rugged landscape should be easily adaptable. Therefore the decision has been made to use a formula to set the fitness level of each patch. The function $sin(xy)(xy)$ has been provided by associate professor dr.ir. I. (Igor) Nikolic in order to set such a rugged landscape. To flatten out the landscape a little the fitness value is divided by four, and resulted into the following line of code.

```
ask patches [
  set value round (rad-sin(pxcor * pycor)*(pxcor * pycor)) / 4
]
```

This line of code lets all the patches take a certain value, the size of the landscape does not matter while using this line of code. Therefore the landscape can be set to an $n * n$ sized landscape, which can be set according the requirements of the experiment. If the landscape would be plotted in a 3D space, it would look something like figure 6.2. This is the standard landscape setting called *"Igor"*. There are other possibilities which can be added easily into the code. As an example a "sombrero" landscape has been added to show the ease of adding other landscapes.

C.2 IMPLEMENTATION EXPLANATION OF CALCULATED RATIO

In equation C.1 the ratio of each patch is calculated. The fitness of the specific patch is divided by the maximum fitness within the range of the agent. This is in order to normalise the fitness value in comparison to the cost. Therefore the cost is also normalised. Both are multiplied with a weight factor $w_{fitness}$ and w_{cost}, both are set by the modeller and represent the behaviour of the venture leaders. They could have a maximising preference (a larger fitness weight) or a satisfying preference (a larger cost weight). The maximising preference suits with a more strategic context perspective. While a satisfying preference suit a more structural context perspective. The cost of moving to a specific patch is calculated by the rounded up distance to a patch see equation C.2.

$$Ratio = 1 + \frac{fitness}{maxfitness} w_{fitness} - \frac{cost}{maxcost} w_{cost} \tag{C.1}$$

The cost of investment within the model are calculated according the distance to the specific patch. This causes the investment to be variable and the closer the agent gets to a specific investment, the lower the price of an investment gets. Equation C.2 also shows *ceil* which means that the result of the square root is rounded up to an integer. This is because half investments cannot happen in the simulation. When all the ratio's are calculated the venture leaders save the information in a list, which represents the venture leaders memory. He then sorts the list on the score of the ratio to map his preferences.

$$cost = ceil\sqrt{(x_{current} - x_{patch})^2 + (y_{current} - y_{patch})^2} \tag{C.2}$$

C.3 DIVERGENCE

The divergence is controlled by setting the simulation into the heterogeneous? mode. With the setting into heterogeneous? mode the variable weight divergence has to be set. The weight divergence is calculated into a factor which is used to create divergence in the simulation. When the model is setup the division managers get created. The division managers start with the set decision values but these get changed according the weight divergence. Each decision variable gets multiplied with 1 minus the divergence factor. A random number then gets multiplied with the divergence factor and the set decision variable, it will then be added to the actual decision variable value. This happens for the decision variables: current fitness, delta fitness, budget, and performance. The decision weight variable uncertainty gets calculated through 1 minus the sum of the other division weights. As the total of the decision weights has to add up to 1.

The same mechanism is applied to the decision weight variable of the venture leaders. As the venture leaders only have two decision weight variables the calculation is performed on the fitness variable. The cost weight variable is calculated through 1 minus the fitness weight variable.

D ADDITIONAL PLOTS FROM THE EXPERIMENTS

D.1 PLOTS FROM EXPERIMENT 4

The following plots are discussed in chapter 8, the plots of figure 8.9 have been sized so the details can be visible. Still there is not a lot of difference to be found.

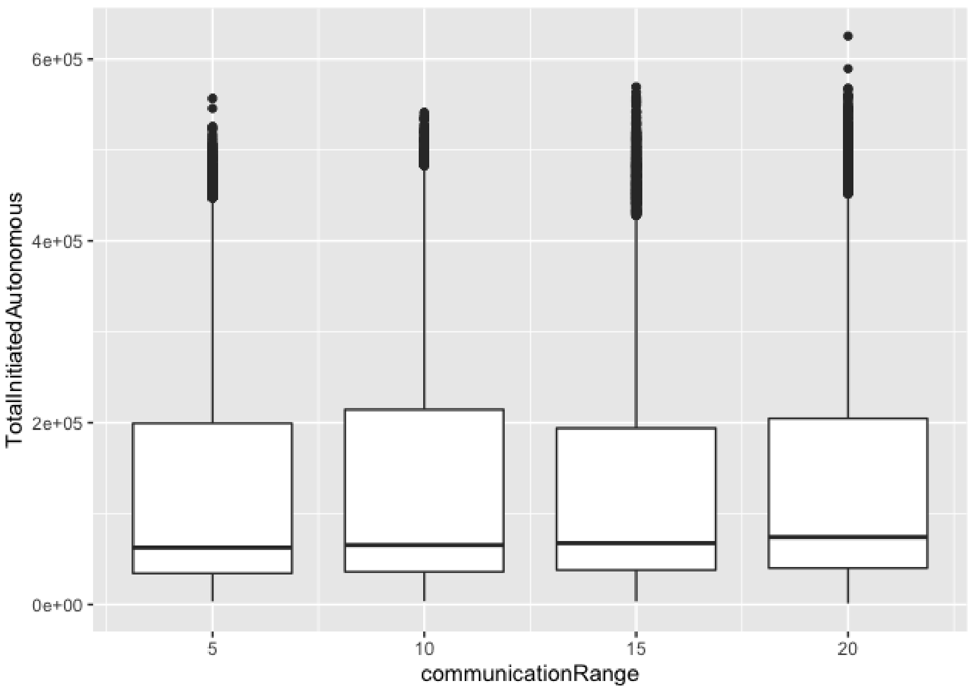

Figure D.1: Total initiated autonomous initiatives per communication range

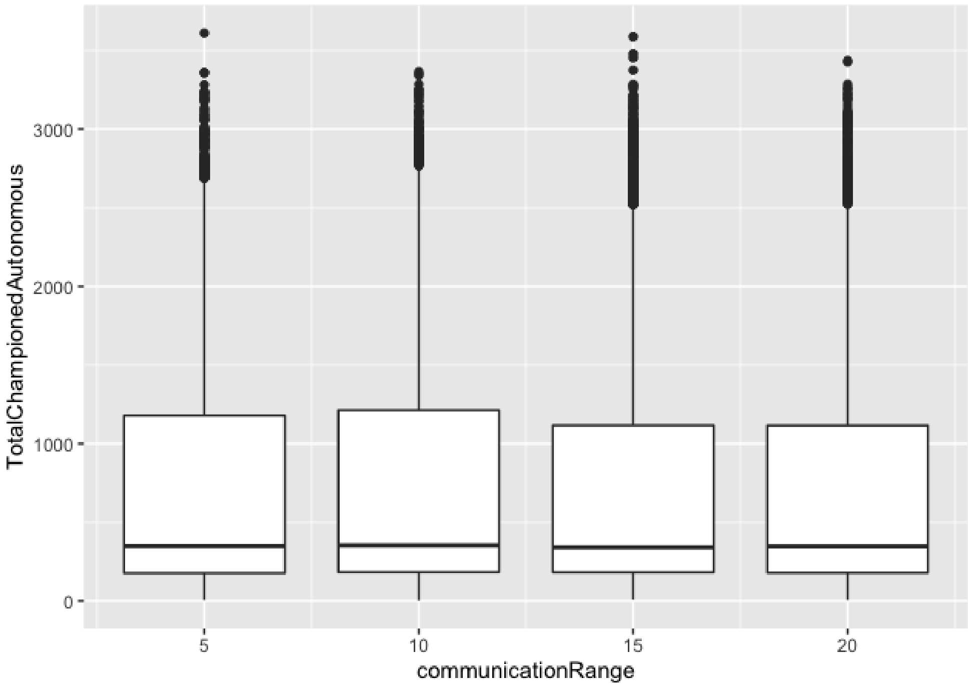

Figure D.2: Total championed autonomous initiatives per communication range

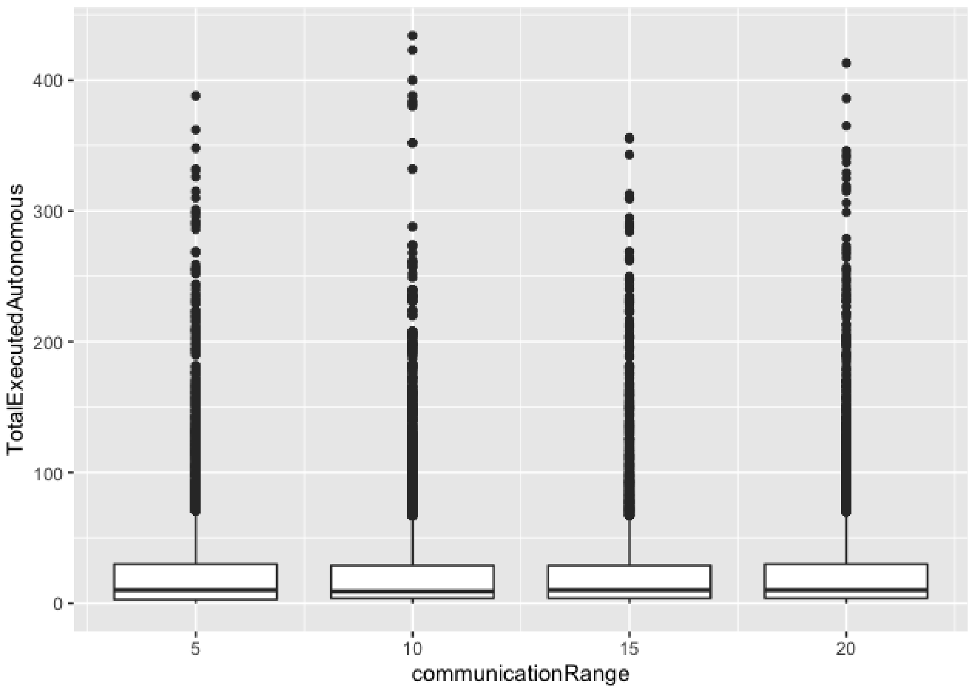

Figure D.3: Total executed autonomous initiatives per communication range

The following plots are the same plots as above, but then show the results per context. These also show almost no difference in increase of communication range.

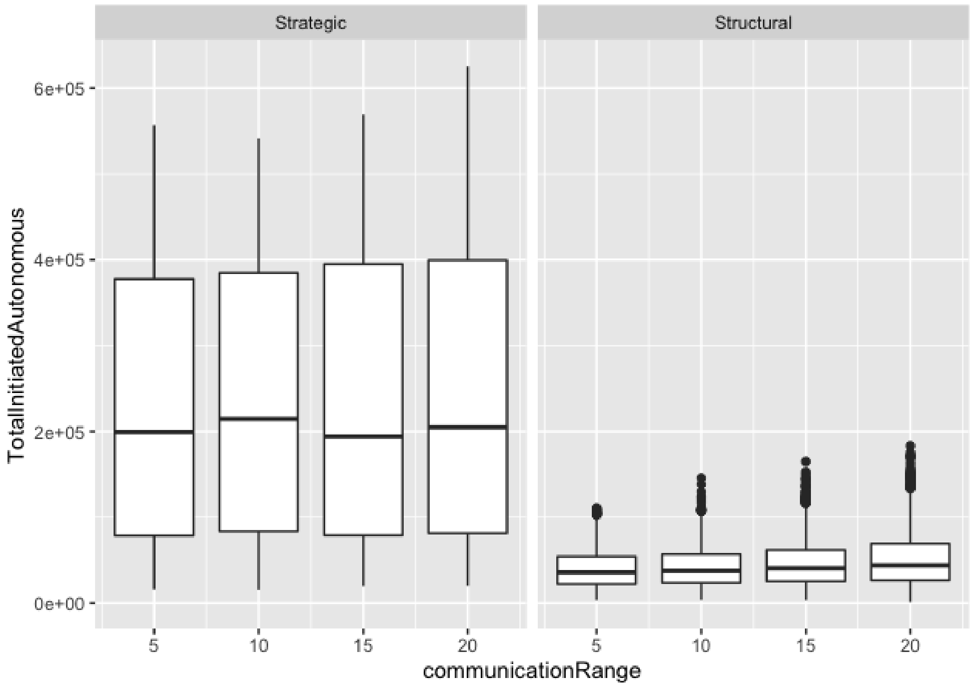

Figure D.4: Total initiated autonomous initiatives per communication range per context

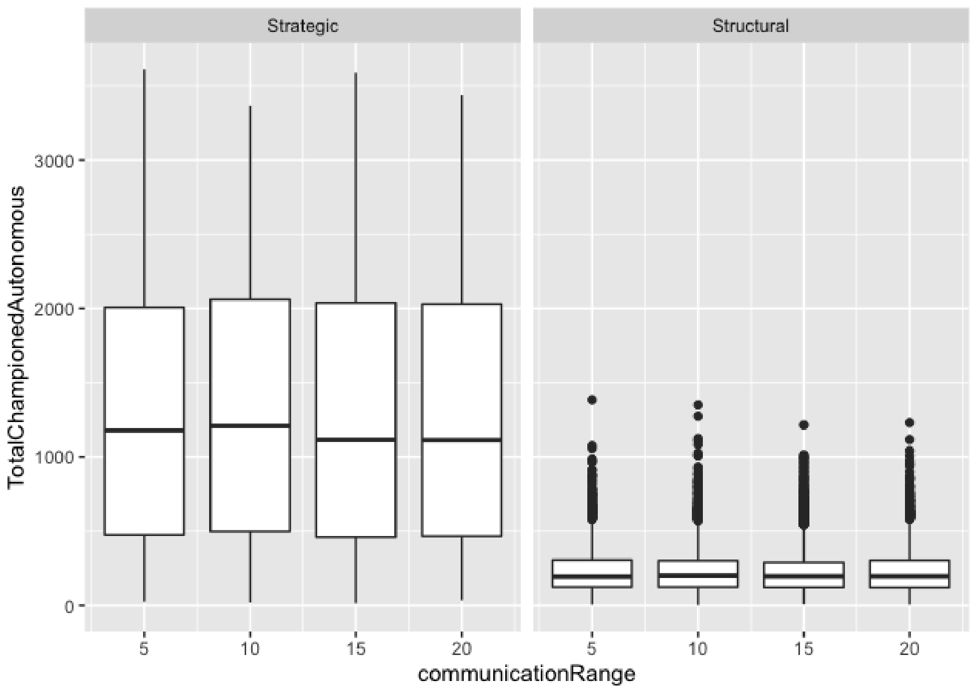

Figure D.5: Total championed autonomous initiatives per communication range per context

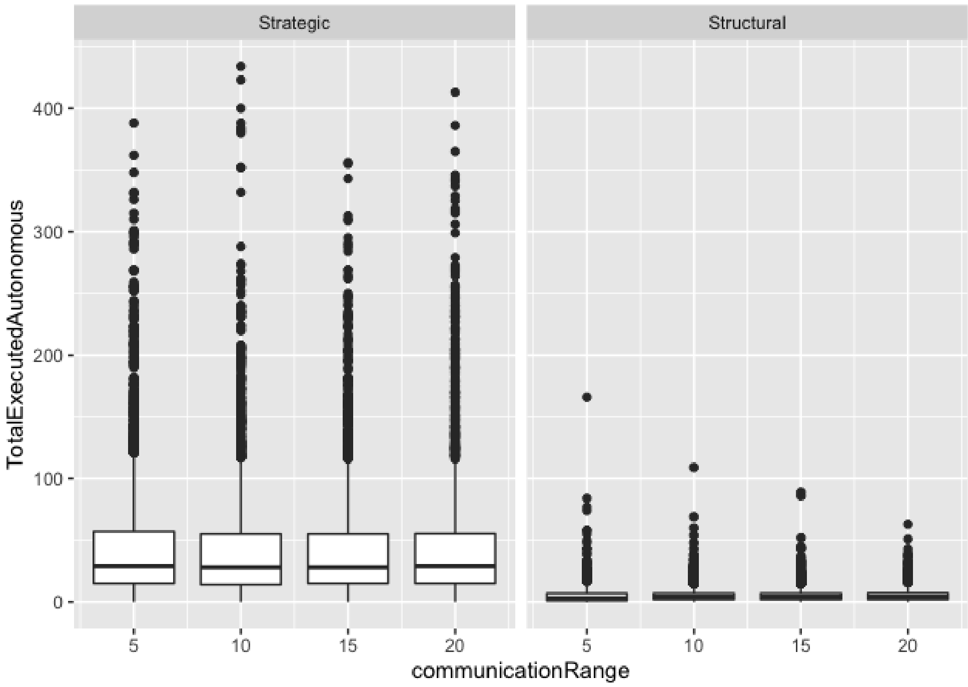

Figure D.6: Total executed autonomous initiatives per communication range per context

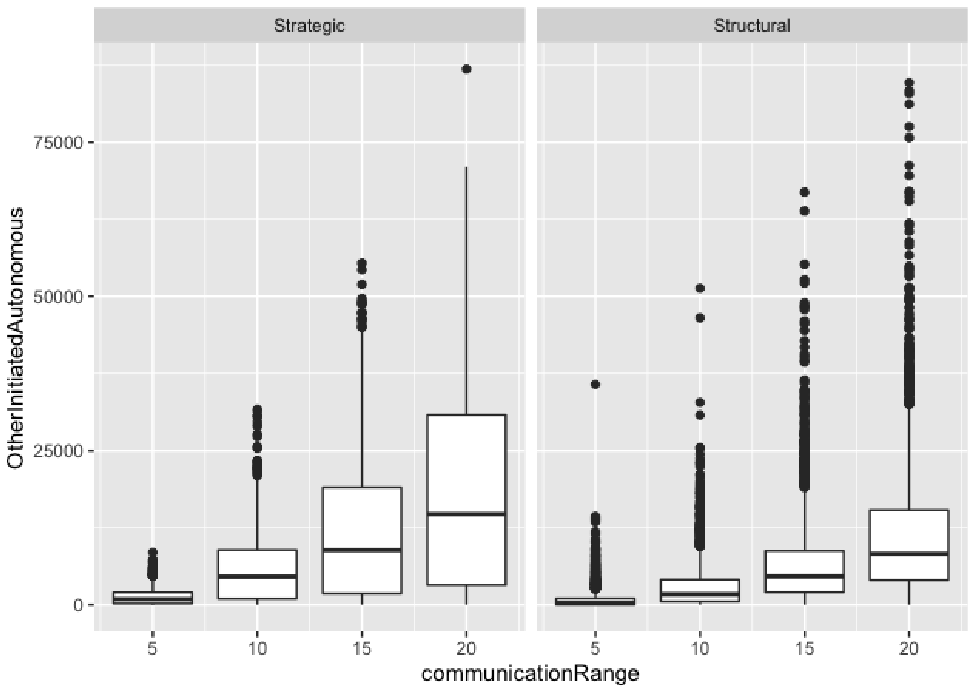

Figure D.7: Other initiated autonomous initiatives per communication range per context

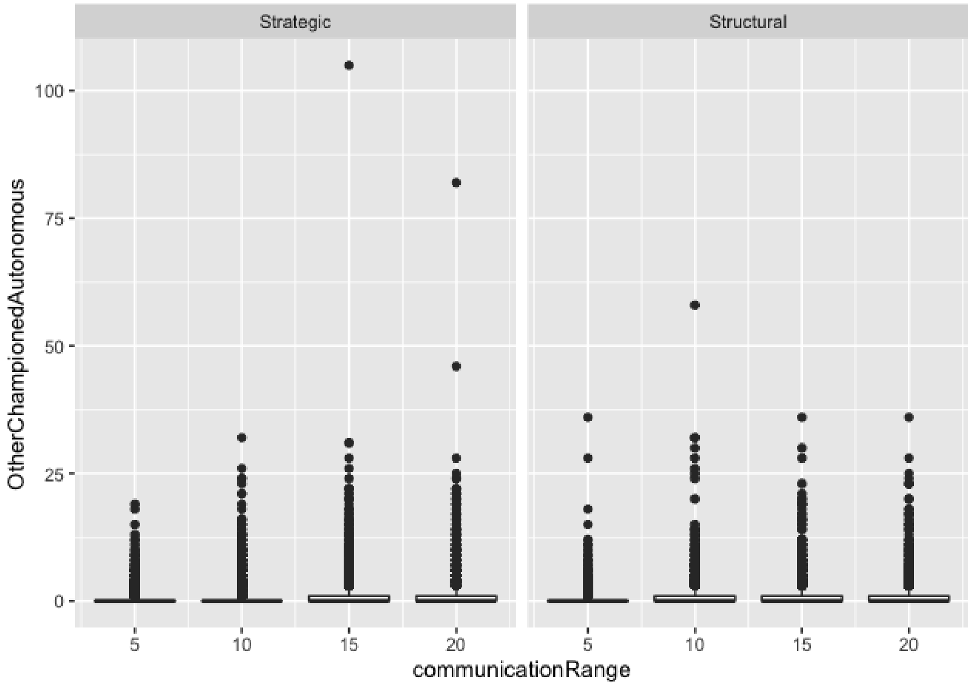

Figure D.8: Other championed autonomous initiatives per communication range per context

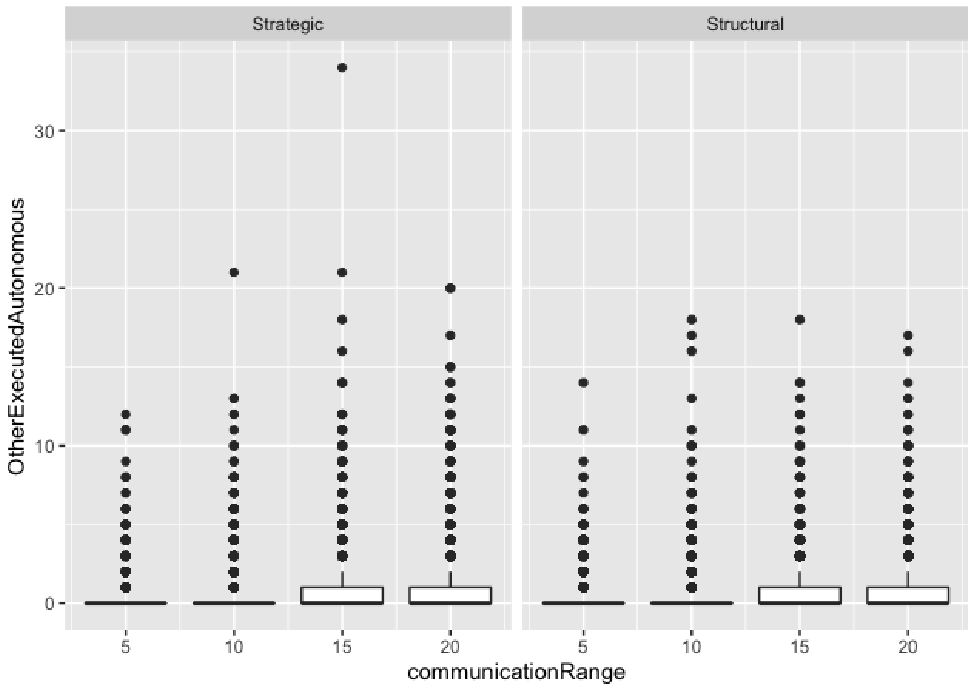

Figure D.9: Other executed autonomous initiatives per communication range per context

E SIGNIFICANCE TESTS

E.0.1 Communication range

Table E.1: P-values of T-tests of communication range

Comm. range	**5-10**	**10-15**	**15-20**
Total initiated	0.0003	0.1753	0.0001
Total championed	0.1104	0.0069	0.5349
Total executed	0.28	0.9733	0.2588
Other executed	<2.2e-16	<2.2e-16	2.2e-8
Strategic	<2.2e-16	1.969e-10	0.0002
Structural	5.055e-16	1.532e-9	6.899e-6

Total initiated autonomous action

Communication range tests on total initiated autonomous action.

```
> t.test(comm10, comm5, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm10 and comm5
t = 3.6077, df = 5999, p-value = 0.0003115
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2168.947 7331.174
sample estimates:
mean of the differences
                4750.06

> t.test(comm15, comm10, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm15 and comm10
t = 1.3554, df = 5999, p-value = 0.1753
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -814.4562 4463.8095
sample estimates:
mean of the differences
               1824.677

> t.test(comm20, comm15, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)
```

```
        Paired t-test

data:  comm20 and comm15
t = 3.8847, df = 5999, p-value = 0.0001036
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2789.062 8471.677
sample estimates:
mean of the differences
               5630.369
```

Because of lack of significance between communication range 10 and 15, an f-test is executed.

```
> var.test(comm15, comm10, alternative = "two.sided")

        F test to compare two variances

data:  comm15 and comm10
F = 1.0347, num df = 5999, denom df = 5999, p-value = 0.1868
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.9836126 1.0883982
sample estimates:
ratio of variances
           1.03468
```

Total championed autonomous

```
> t.test(comm10, comm5, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm10 and comm5
t = 1.5966, df = 5999, p-value = 0.1104
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.923884 28.587884
sample estimates:
mean of the differences
                 12.832

> t.test(comm15, comm10, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm15 and comm10
t = -2.6979, df = 5999, p-value = 0.006998
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -37.530902  -5.942098
sample estimates:
mean of the differences
```

```
             −21.7365

> t.test(comm20, comm15, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t−test

data:  comm20 and comm15
t = 0.62062, df = 5999, p−value = 0.5349
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 −11.20395  21.58429
sample estimates:
mean of the differences
              5.190167
```

Total executed autonomous

```
> t.test(comm10, comm5, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t−test

data:  comm10 and comm5
t = −1.0805, df = 5999, p−value = 0.28
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 −1.8466882  0.5343549
sample estimates:
mean of the differences
            −0.6561667

> t.test(comm15, comm10, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t−test

data:  comm15 and comm10
t = −0.033423, df = 5999, p−value = 0.9733
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 −1.163221  1.124221
sample estimates:
mean of the differences
               −0.0195

> t.test(comm20, comm15, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t−test

data:  comm20 and comm15
t = 1.1292, df = 5999, p−value = 0.2588
alternative hypothesis: true difference in means is not equal to 0
```

```
95 percent confidence interval:
 -0.4822158  1.7925491
sample estimates:
mean of the differences
              0.6551667
```

Other executed autonomous

```
> t.test(comm10, comm5, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm10 and comm5
t = 13.022, df = 5999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.2243988 0.3039345
sample estimates:
mean of the differences
              0.2641667

> t.test(comm15, comm10, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm15 and comm10
t = 8.813, df = 5999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1919276 0.3017391
sample estimates:
mean of the differences
              0.2468333

> t.test(comm20, comm15, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm20 and comm15
t = 5.5998, df = 5999, p-value = 2.241e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1201278 0.2495389
sample estimates:
mean of the differences
              0.1848333

> mean(comm5)
[1] 0.2233333
> mean(comm10)
[1] 0.4875
> mean(comm15)
[1] 0.7343333
```

```
> mean(comm20)
[1] 0.9191667
```

Thus there is a significant increase. This means that the communication works but it has a very small influence. There even are runs where there is no communication used.

Other executed strategic

```
> t.test(comm10, comm5, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm10 and comm5
t = 10.119, df = 2999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.241869 0.358131
sample estimates:
mean of the differences
                    0.3

> t.test(comm15, comm10, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm15 and comm10
t = 6.3858, df = 2999, p-value = 1.969e-10
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1880210 0.3546457
sample estimates:
mean of the differences
              0.2713333

> t.test(comm20, comm15, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm20 and comm15
t = 3.6298, df = 2999, p-value = 0.0002884
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.08659915 0.29006752
sample estimates:
mean of the differences
              0.1883333
```

Other executed structural

```
> t.test(comm10, comm5, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)
```

Table E.2: P-values of T-tests of weight divergence

Divergence	0-20	20-50	50-80
Total initiated	2.158e-8	<2.2e-16	<2.2e-16
Total championed	<2.2e-16	<2.2e-16	<2.2e-16
Total executed	<2.2e-16	<2.2e-16	<2.2e-16

```
        Paired t-test

data:  comm10 and comm5
t = 8.1555, df = 2999, p-value = 5.055e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1719182 0.2807485
sample estimates:
mean of the differences
              0.2263333

> t.test(comm15, comm10, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm15 and comm10
t = 6.0599, df = 2999, p-value = 1.532e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1492675 0.2920659
sample estimates:
mean of the differences
              0.2206667

> t.test(comm20, comm15, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  comm20 and comm15
t = 4.5047, df = 2999, p-value = 6.899e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1039113 0.2640887
sample estimates:
mean of the differences
                  0.184
```

E.0.2 Divergence

Total initiated autonomous structural

```
> t.test(divergence0, divergence20, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test
```

```
data:  divergence0 and divergence20
t = 5.6026, df = 11999, p-value = 2.158e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1033.798 2146.470
sample estimates:
mean of the differences
               1590.134

> t.test(divergence20, divergence50, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence20 and divergence50
t = 21.246, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 5204.365 6262.301
sample estimates:
mean of the differences
               5733.333

> t.test(divergence50, divergence80, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence50 and divergence80
t = 18.927, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 4356.546 5363.151
sample estimates:
mean of the differences
               4859.849
```

Total championed autonomous

```
> t.test(divergence0, divergence20, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence0 and divergence20
t = 34.663, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
  93.83295 105.08138
sample estimates:
mean of the differences
               99.45717

> t.test(divergence20, divergence50, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)
```

```
        Paired t-test

data:  divergence20 and divergence50
t = 42.505, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 73.78115 80.91518
sample estimates:
mean of the differences
               77.34817

> t.test(divergence50, divergence80, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence50 and divergence80
t = 33.35, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 36.42277 40.97173
sample estimates:
mean of the differences
               38.69725
```

Total executed autonomous

```
> t.test(divergence0, divergence20, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence0 and divergence20
t = 16.559, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1.357184 1.721649
sample estimates:
mean of the differences
               1.539417

> t.test(divergence20, divergence50, mu=0, alternative = "two.sided",
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence20 and divergence50
t = 28.755, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1.276068 1.462765
sample estimates:
mean of the differences
               1.369417

> t.test(divergence50, divergence80, mu=0, alternative = "two.sided",
```

```
paired = T, conf.level = 0.95)

        Paired t-test

data:  divergence50 and divergence80
t = 25.665, df = 11999, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.6810960 0.7937373
sample estimates:
mean of the differences
              0.7374167
```

F NETLOGO CODE

The NetLogo and RStudio scripts developed for this research are uploaded to a GitHub repository which can be accessed on: https://github.com/ddeplanque/rap-abm

TU Delft