Master Thesis Business Information Technology

Performance of Alliance Portfolio Configuration Strategies under Strategic Uncertainty: An Agent-based simulation approach

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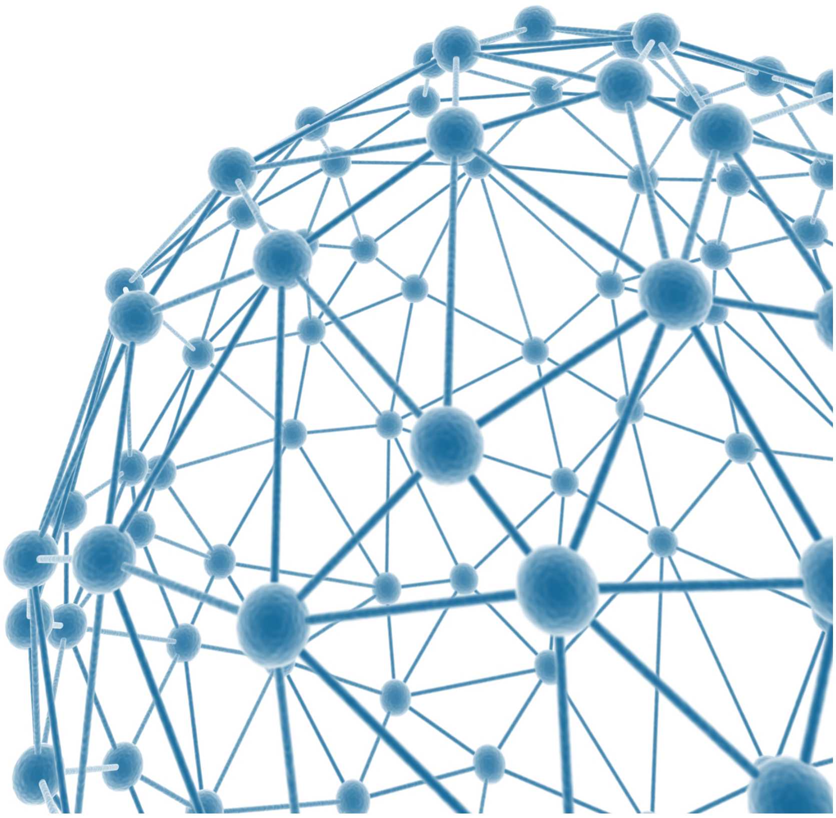

UNIVERSITY OF TWENTE.

Concordia University
John Molson
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Master Thesis of Floris Jansen;

"Performance of Alliance Portfolio Configuration Strategies under Strategic Uncertainty: An Agent-based simulation approach"

June 24, 2011

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SUMMARY

Alliance management and in the case of multiple alliances alliance portfolio management is recognized as increasingly important for businesses. The decisions to change the alliance portfolio configurations are based on alliance portfolio configuration strategies, which are closely linked to the business strategy, and are mainly based on the perceived strategic uncertainty in the industry.

In our research we are interested in the following question:

How is the performance of alliance portfolio configuration strategies influenced by strategic uncertainty?

This research question actually consists out of two sub-questions:

1. What is the influence of strategic uncertainty on the alliance portfolio configuration performance?
2. What is the influence of strategy on the alliance portfolio configuration?

Hoffmann (2007) studies the influence of uncertainty on, the strategies and the performance of alliance portfolio configurations. His research does combine a lot of the alliance portfolio background theories to create a general consensus on how configurations and strategy can be based on the environment and can influence the performance. But as with a lot of studies in alliance portfolios research the empirical test method is very static and constrained to a certain type of environment. Simulation-based methods are an upcoming method used to counter these constraints.

We started by enhancing the proposed model of Hoffmann (2007) by making some changes that generalized the framework. (1) First in the resource based view we went back to a general accepted classification of resources of Capron et al. (1998) namely: research & development, manufacturing, marketing, managerial, and financial resources. (2) By making these changes the shaping potential's capital theory of Ahuja (2000) gave us the three actions a firm is able to perform to influence the alliance portfolio strategy: (a) produce, (b) deliver and (c) change alliance portfolio configuration. (3) The next change we made is to change the strategies Hoffmann (2007) defines back to the original theory of March's (1991): Exploration vs. Exploitation.

All these changes allowed us to answer the sub questions. According to our proposed framework when the strategic uncertainty grows the redundancy and linkage intensity is influenced in a negative way and the size and dispersion is influenced in a positive way. The performance is influenced by a growing resource endowment that improves the delivery opportunities of the firm. Performance in this case is generated by the sales of products to the industry. And furthermore the exploitation strategy influences the alliance portfolio configuration by having a focus on redundancy and intensity, and the exploration strategy has a focus on size and dispersion.

In the next step we improved the empirical analysis of the framework by creating an agent-based simulation. We chose to create this simulation in NetLogo, as this tool creates an easy to use environment and has the build in ability to create visual feedback of the changes in the alliance portfolios of the different firms.

From the data gathered from the simulation we answered our question and we conclude that the exploration strategy performs badly under low uncertainty conditions; while under high uncertainty conditions the performance of the strategy is equal to the exploitation strategy. To the contrary, the exploitation strategy is not heavily influenced by the uncertainty or certainty of the environment.

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PREFACE

In September 2009 I addressed my interest in performing a master thesis research that needed to combine alliance portfolio research and agent-based simulations. This research was an idea of two good friends Prof.dr. J. van Hillegersberg and U. Wassmer Ph.D.. As the research looked promising and offered the opportunity to visit Canada, I committed to create a proposal and see if the research and the visit were feasible goals.

From September till February 2010 we were able to arrange a visit to Canada for 7 months. I explicitly chose for a longer period so that I could use the summer period as optimal as possible for working on my thesis as well as really testing and developing my personal skills. We were also able to work out a proposal of what we wanted to achieve; which contained some very comprehensive goals for a master thesis: (1) create a literature review of the alliance portfolio research area, (2) create a literature review of the agent-based simulation research area, (3) create a agent-based simulation from scratch (4) gather academically interesting data out of this simulation and (5) create a master thesis that could be the basis for at least one publication.

I'm proud to say that in the duration of a year we reached all the goals, where the result is laying in front of you. And U. Wassmer Ph.D. also has expressed the commitment of writing a paper, together with Prof.dr. J van Hillegersberg and myself, which hopefully will be publishable around December 2011.

All these results wouldn't be possible with the extensive guidance and effort of U. Wassmer Ph.D. in a personal sense, by among others providing shelter for the first two weeks in Montreal as well as academically with all the meetings, in person as well as on Skype. Furthermore I would like to thank U. Wassmer Ph.D. and his department of management of the John Molson School of Business of the Concordia University for providing the office space and materials during my stay in Canada. I also want to thank my guides from the University of Twente; Prof.dr. J. van Hillegersberg and Dr. P.A.T. van Eck, for reviewing the documents and guiding me to create a flow in the Master Thesis.

Overall I'm looking back at a great experience in an academic as well as a personal sense. I'm convinced that this experience enhanced me as a person and that I'm ready for the opportunities that lay ahead, starting with my new job at Deloitte Consulting.

Enschede, June 24 2011

Floris Jansen

INTRODUCTION

In this research we study the influence of strategic uncertainty on the performance of alliance portfolio configuration strategies. The research creates a unique combination of alliance portfolio research with agent based simulation research. In this first chapter we outline the motivation and organization of our research and furthermore we specify our research approach, research questions and objectives.

Motivation

Alliance portfolios can be defined as a set of links from one actor to other actors, representing some relationship. Actors can be individuals, work units, or organizations. Traditional alliance research mainly focuses on the formation, governance, evolution, and performance of single alliances (Wassmer, 2010). More recently researchers have taken a firm level perspective and started to examine alliance portfolios; the engagement of a firm in multiple simultaneous alliances with different partners (Hoffmann, 2007; Levinthal, 1997; Wassmer, 2010). We will give an example, based on how this research started, that shows how alliances can benefit from each other and furthermore how connections of alliance partners can create new connections to execute opportunities:

> Jos shared knowledge with Ulrich based on this "alliance" they created a rough idea (*research opportunity*) about combining simulations and alliance portfolios. Because of a lack of (among others) knowledge and time (*demand for resources*) they decided not to pursue this idea. Jos and Floris also had a connection through sharing knowledge in a teacher student relation (an other alliance out of the alliance portfolio of Jos). Floris actually was searching for a way of graduating and approached Jos for any options (*offer of resources)*. At this point Jos brought together Floris and Ulrich, based on the complementary capabilities, which evolved into a *new alliance* that is able to execute the plans. All this changed the alliance portfolio of Jos, Ulrich and Floris, enlarging the possibility for Jos and Ulrich to conduct joint research and publish a paper and for Floris to graduate (*performance*).

Business level changes in the business network are comparable to the example, off course it is different because on a business level the firm is often involved with a lot more actors and decisions made have a greater impact. To manage all these individual alliance we already introduced the alliance portfolios but the decisions to change the alliance portfolio configurations are based on alliance portfolio configuration strategies. Alliance portfolios configuration strategies are connected to the firms' strategic choices based on: (1) the firm's current position in the entire industry and its ability to shape the architecture of the industry, (2) the decisions to engage with other firms to exploit opportunities, and (3) the approach on how to deal with the perceived[1] uncertainty of the industry (Hoffmann, 2007; Wassmer, 2010). All these three choices can be referred to as the strategic uncertainty of the industry.

Research Questions and Objectives

In our research we are interested how alliance portfolio configuration strategies change alliance portfolios under strategic uncertainty to create business opportunities and influence the performance. To represent this goal we created the following main research question:

How is the performance of alliance portfolio configuration strategies influenced by strategic uncertainty?

This research question actually consists out of two sub-questions:

1. What is the influence of strategic uncertainty on the alliance portfolio configuration performance?
2. What is the influence of strategy on the alliance portfolio configuration?

Research Approach

Hoffmann (2007) studies the influence of uncertainty on, the strategies and the performance of alliance portfolio configurations. That research however doesn't empirically test their proposed model. We will adapt the theories used in the Hoffmann paper to propose our own more general version of the model. We use a simulation approach to simulate the changes in the alliance portfolio configuration under different

[1] "Empirical studies prove that it is not the objective extent of environmental uncertainty but rather the subjectively perceived amount of environmental uncertainty that primarily influences the decision behavior. But, of course, the more similar the perceived environmental uncertainty (ex ante) with the actual volatility of the environment (ex post), the better the choice of strategy and the performance of the company." p833 of; Hoffmann, W. 2007. Strategies for managing a portfolio of alliances. ***Strategic Management Journal***, 28(8): 827-856.

uncertainties. Hoffmann (2007) does have propositions he tests based on some case study-based data. In our research using our agent-based simulation we take this subjectivity out of the equation. The results of the simulation are compared to the conclusion of Hoffmann (2007).

Simulations enable theorists to test their theory in a computational representation. Simulation-based research has gained recognition as a significant methodological approach to produce empirical data, provide an analytically precise method to specify and explain theoretical logic, and reveal outcomes of theories, as they would develop over time (Davidsson, 2001; Davis, Eisenhardt, & Bingham, 2007; Jager, 2007; Parker, Manson, Janssen, Hoffmann, & Deadman, 2003).

So our research covers two major research areas (1) alliance portfolios and (2) agent-based simulations. We divide our research in three stages. We start off with exploring the literature. In this exploration phase we explain the different terms used and work towards the analysis of the Hoffmann (2007) research. At the end of this phase we propose our adapted model based on Hoffmann (2007). In the second phase of the research we select a simulation tool that is used to create our simulation. In this phase we start off with a design of our agent-based simulation, select the best tool, and eventually create the actual simulation out of this design, using an iterative design approach. While creating the simulation, when faced with limitations or possibilities in the simulation, we update the design. After finishing the simulation we are ready to generate data. The data is generated based on test cases that will validate the proposed model. After the execution phase we are able to answer the research questions. Figure 1 shows a representation of this structure.

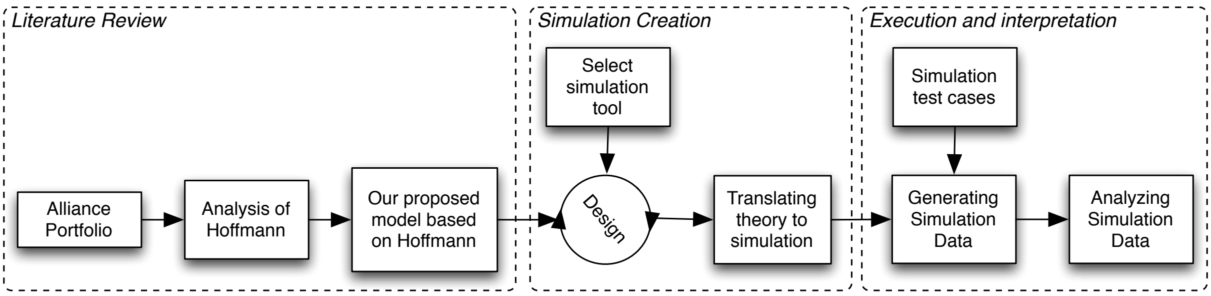

Figure 1 - Research Structure

The different phases also create the framework for the research thesis. The next section contains a literature review phase, followed by the simulation phase and eventually end with the execution and interpretation phase, leading to the conclusion of our research.

Organization

The research is executed in three main parts (1) preparation for research in Canada and finalizing the research proposal, (2) the literature review, simulation creation and (3) the execution and interpretation of data of the simulation. The first and last part of the research is executed at the University of Twente in the Netherlands, the second part is executed in Canada at John Molson School of Business at Concordia University in Montréal, Quebec, Canada. The reason for this division is based on knowledge and time constraints; Ulrich Wassmer PhD, assistant professor at the John Molson School of Business, has extensive knowledge of alliance portfolios and we had the possibility to work together for the whole summer on the theoretical part of this research.

PHASE 1: LITERATURE REVIEW

In the literature review phase we explore the research area of alliance portfolios. We start by reviewing the current research in the field of alliance portfolios. And then provide a summary of the Hoffmann (2007) paper. Finally, with the gained knowledge of alliance portfolios, we analyze the Hoffmann (2007) paper and propose our adapted model.

Chapter 1: Strategic Alliance Portfolios

In academic literature researchers generally seem to agree that strategic alliances are any form of strategic cooperative collaboration involving two or more companies (Ahuja, 2000; Contractor & Ra, 2000; Grant & Baden-Fuller, 2005; Hoffmann, 2007). Company involvement in alliances is a method to fulfil the need for a business to create a fit between the business' strategy and structure with the conditions of the environment, as explained by contingency theory (Davis, Eisenhardt, & Bingham, 2009; Donaldson, 2001; Eisenhardt & Schoonhoven, 1996; Hofer, 1975).

When we take a look at alliance portfolios the definition seems not as clear. One of the reasons for this is that alliance portfolios have been researched from diverse fields of studies resulting in the same differences in conceptualization issues as the resource definitions discussed above. The most common, and also our, approach is to look at an alliance portfolio as the collection of all strategic alliances of a focal firm (Hoffmann, 2007; Parise & Casher, 2003; Wassmer, 2010). There are three issues creating the confusion on what an alliance portfolio constitutes: (1) the types of alliances included and excluded (2) the level of the alliance portfolio (business or corporate level) (3) the inclusion or exclusion of past alliances (Wassmer, 2010). To ensure the clearness of the term alliance portfolio we try to clarify these three elements.

Collaboration as described in alliances in most cases involves the transfer or sharing of resources (Brueckner, 2001; Burgess & Robinson, 1969; Contractor & Ra, 2000; Eisenhardt & Schoonhoven, 1996; Grant & Baden-Fuller, 2005; Hoffmann, 2007; Wassmer, 2010). The term resources has a very indistinct meaning, where different authors give different meaning to resources. In most cases the definition of resources comes together with the focus of research. Grant & Baden-Fuller (2005) are describing methods to access knowledge through alliances, so in their research the resources shared via an alliance is knowledge. Other similar examples can be found in Kogut (2000) and Mowery, Oxley & Silverman (1996). Another example of the usage of resources in an alliance context is the division in "technical capital, commercial capital, and social capital" (Ahuja, 2000), which is also incorporated in the research of Hoffmann (2007). In this perspective resources are seen as factors that can provide a competitive advantage and are therefore more clustered around the areas of influence. The last example of resource definition is a more "traditional" view of resources like "raw materials, information, human and financial resources" (Daft, 2003) or "research & development, manufacturing, marketing, managerial, and financial resources" (Capron, Dussauge, & Mitchell, 1998). There the focus is more based on systems theory where there are inputs (resources) going through a transformation process leading to certain outputs.

Wassmer (2010) created a literature review of the current alliance portfolio literature, addressing the emergence, configuration and management of alliance portfolio, see figure 2. We will use this review and the same order of subjects to give an overview of the current literature about alliance portfolios.

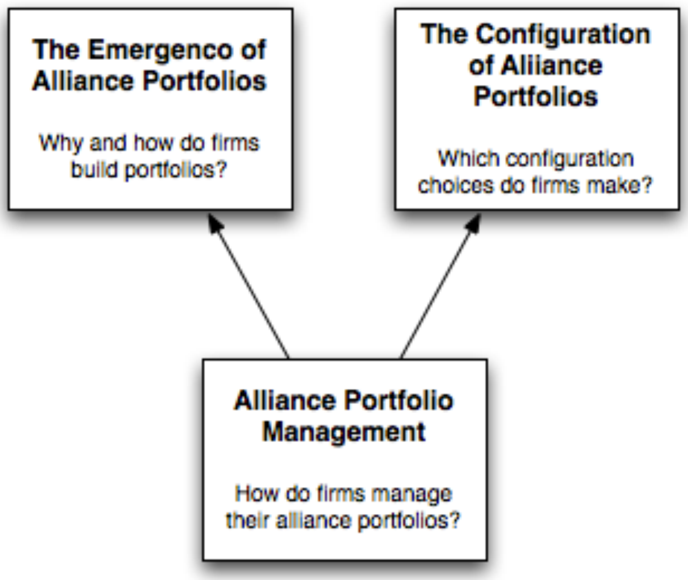

Figure 2 - Conceptual Map of Alliance Portfolio Research Areas (copied from (Wassmer, 2010))

1.1: The Emergence of Alliance Portfolios

The emergence literature gives us the answer to the questions why and how firms build alliance portfolios. Alliance portfolios are of course eventually the combination of all single alliances, where all these alliances have their own strategic reason to be formed. The main reason to combine this into a portfolio is the ability to follow a certain alliance portfolio strategy based on the business' strategy. Next to this motivation there are some strategic rationales why firms build alliance portfolios: (1) managing risk and uncertainty in the industry, (2) exploit opportunities by enhancing of a firm's resource stock and capacity to earn relational rents, (3) exploit structural holes or increase the social capital by which the firm is able to shape the architecture of the industry, and (4) the acceleration of learning on how to design and manage alliances. Next to expanding the alliance portfolio with new alliance partners there is a reason to engage in new alliances with already existing alliance partners: create a higher level of trust. This trust influences the probability of future alliance formation and decision about future governance structures of the alliance, furthermore it enlarges the possibility to engage in an alliance with a prior alliance partner or with an indirect partner, meaning a partner from a trusted alliance partner.

1.2: The Configuration of Alliance Portfolios

Alliance portfolio configuration is about the arrangement of the individual alliances and their content collected in the alliance portfolio. The configuration consists of a combination of dimensions including (1) size; number of alliances, (2) structure; often including breadth, depth and redundancy within the portfolio, (3) relational strength; representing the trust and importance of the individual alliances, and (4) content; which includes the partner-related characteristics. The configuration of alliance portfolio's essentially determines (1) the quality, quantity, and diversity of information and resources to which the focal company has access, (2) the efficiency of the access to these network resources, and (3) the flexibility or stability of the focal company's position in the inter-organizational field (Wassmer, 2010).

An under-researched but very important issue in alliance portfolio research is the outcome of synergy or conflict out of interdependencies in alliance portfolios. These synergy and conflict is referred to as the portfolio effect, which makes that the overall value created by an alliance portfolio is greater or smaller than the sum of all individual alliances. (Harrison, Lin, Carroll, & Carley, 2007)

1.3: Alliance Portfolio Management

Individual managers are important in the management of alliance portfolios. The managers own interest and efforts to obtain private benefits from creating or expanding an alliance portfolio can harm the interest of the focal firm (Reuer & Ragozzino, 2006). Therefore it is even more important to have alliance portfolio management at the firm-level. The firm-level capability is not just created by having more alliances but rather through experience and the sharing and education of this experience. Having good learning mechanisms in place will cause the managers and executives to gain experience in managing single and multiple alliances.

1.4: Research Gap

Recent research has taken a firm level perspective and started to examine alliance portfolios, i.e. the engagement of a firm in multiple strategic alliances with different partners. Researchers have used various research methods and design to study strategic alliances including quantitative design (Eisenhardt & Schoonhoven, 1996; Grant & Baden-Fuller, 2005), and case studies (Hoffmann, 2007; Kapmeier, 2008; Mowery et al., 1996). These studies are generally very static or constrained to a certain type of environment (Wassmer, 2010). One of the options to enhance the alliance portfolio data is by using simulation-based methods. Although its increasing popularity under the management research, in the field of alliance research it is still an underused method, that merits further research. For example in Hoffmann (2007) the research is limited to two cases where the research of Hoffmann (2007) does combine a lot of the alliance portfolio background theories to create a general consensus on how configurations and strategy can be based on the environment and can influence the performance. Using a simulation based method we might be able to generalize this theory.

Chapter 2: Analysis of Hoffmann (2007)

As stated in the introduction of this report, our research is mainly based on Hoffmann's (2007) paper on portfolio management strategies. Hoffmann's (2007) research focuses on businesses reaching their strategic goals by using a bundle of their alliances, thus placing the structure and strategic orientation of the whole alliance portfolio at the center of interest. The Hoffmann's (2007) research attempts to cover four elements: "(1) to develop a strategy typology for alliance portfolios; (2) to determine how the selected strategy affects the way the alliance portfolio is configured; (3) to identify the contingency factors influencing the choice of portfolio strategy; and (4) to show the effects of portfolio strategy on the resource endowment and performance of the focal business unit" (Hoffmann, 2007).

Hoffmann's research is built on a contingency-based approach where alliances can be viewed as the firm's "adaptive behavior to maintain a match between firm strategy and resource endowment on the one hand and changing environment conditions on the other" (Hoffmann, 2007, p829). As we discuss, in Chapter 1, there are some important issues to settle on the meaning of an alliance portfolio (1) the types of alliances included and excluded, (2) the level of the alliance portfolio (business or corporate level), and (3) the inclusion or exclusion of past alliances. Hoffmann (2007): (1) alliances are used "as the generic term for all types of cooperative inter-organizational relationships that want to create and/or protect competitive advantage" (Hoffmann, 2007, p827 (footnote 1)), (2) alliance portfolio strategies are defined at the business level, (3) past alliances are not regarded in the alliance portfolio configuration.

2.1 Strategy Typology

Hoffmann's first contribution is his strategy typology, in which he distinguishes three strategies that companies use when forming their alliance portfolios. Hoffmann adapted these strategies from (March, 1991). According to March (1991), companies can either exploit the current resource endowment and wait to develop new resources and capabilities until uncertainty has been reduced or, through exploration, try to change the resource base and take earlier advantage of opportunities created by the environmental evolution. Hoffmann adapts these exploration and exploitation strategies with three ways of coping with a complex and changing environment; (1) an exploration *shaping strategy* with the strategic intent to develop new resources and capabilities and to explore new opportunities, (2) an exploration *adapting strategy* which aims to reactively adapt to the uncertainty in the environment by broadening the resource base, and (3) an exploitation *stabilizing strategy* that tries to refine and leverage the resources to achieve a sustained an efficient exploitation of established competitive advantages.

A firm's inducement to form alliances can be related to its need for resources. As based on the contingency theory used by (Ahuja, 2000; Eisenhardt & Schoonhoven, 1996) the larger the gap between the firm's resource endowment and the environmental demands, combined with the quickness this deficit has to be overcome, the greater the need for alliances. The opportunity of a firm to form an alliance depends also on the position, the resource attractiveness, of the firm in relation to other firms. Resource endowment is specified by using the resource categorization of Ahuja (2000); (1) technical capital that represents a firm's capability to innovate, (2) commercial capital is a firm's capability to produce and deliver to the market, and (3) social capital represents the benefits from its inter-organizational relationships. The other aspect according to Hoffmann that influences the choice of alliance portfolio strategy is the strategic uncertainty. This strategic uncertainty is specified as the perceived environmental uncertainty in relevant environmental sectors, weighted with the perceived relative importance of the individual sectors. Hoffmann created a diagram to represent when to use which strategy, see figure 3.

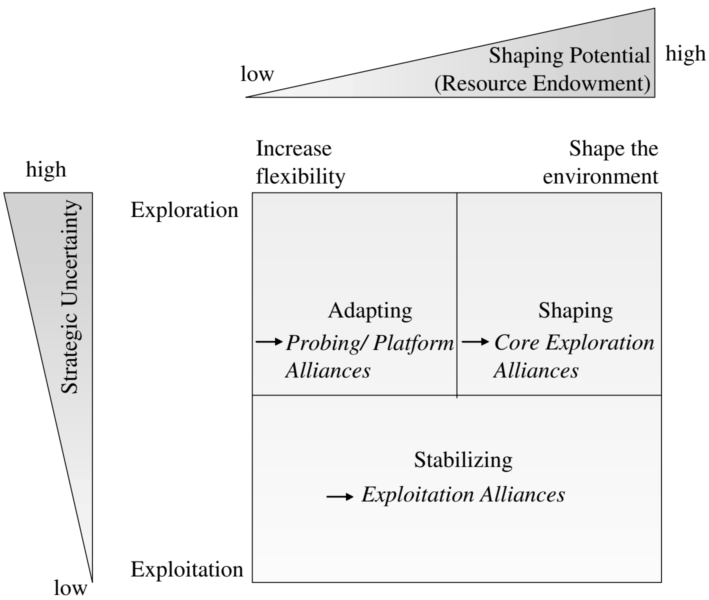

Figure 3 - Types of alliance strategy (copied from (Hoffmann, 2007, figure 1, p832))

2.2: Dynamics in Alliance portfolio configurations

The alliance strategy determines the configuration of the alliance portfolio. Essential configuration parameters of alliance portfolios are the number, dispersion, and redundancy of the alliances plus their linkage strength. The four parameters for configuring alliance portfolios determine (1) the quality, quantity, and diversity of information and resources to which the focal company has access, (2) the efficiency of the access to these network resources, and (3) the flexibility or stability of the focal company's position in the inter-organizational field.

Based on the strategy typology and the theoretical underpinning Hoffmann considers the following parameters: (1) strategic uncertainty, (2) shaping potential, and (3) alliance strategy, which is closely linked to the configuration of the alliance portfolio. To analyze the effects of the changes in alliance portfolios on firm performance, the focal firm's financial performance also has to be included in this framework. Hoffmann uses a cause-effect diagram to visualize the influences of all the parameters. We combined the three different diagrams show in Hoffmann (2007, figure 2 to 4) into one (figure 3).

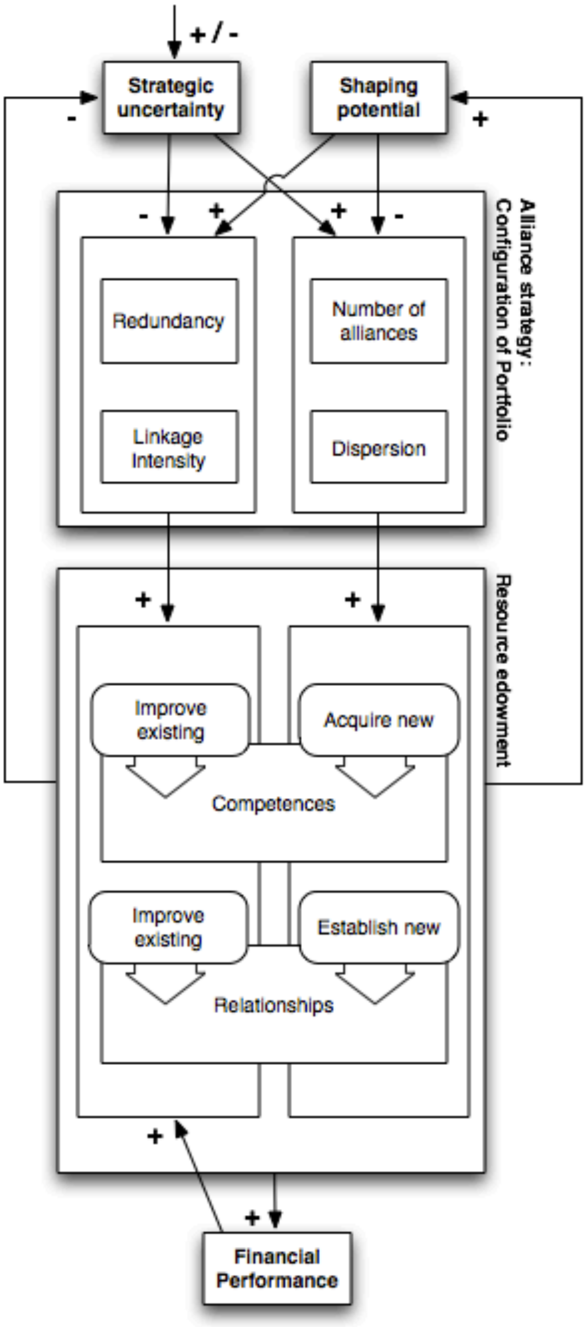

Figure 4 - Cause-effect diagram (Compiled out of (Hoffmann, 2007))

We'll explain the cause-effect diagram in short, starting with the strategic uncertainty. According to Hoffmann (2007) there are four sources of uncertainty: (1) technological uncertainty, (2) commercial uncertainty, (3) social uncertainty and (4) regulative uncertainty. The first three types of uncertainties are directly linked to the shaping potential, the fourth can be seen as a general uncertainty created by demographic factors, i.e. rules and regulation that differ in certain areas.

The firm's business strategy is directly linked with the alliance strategy used (Hoffmann, 2007). The choice of strategy is connected to the contingency factors of the industry. One of the main inducements is the need for resources generated by the gap between the current resource endowment and the expected demand. The accuracy, flexibility and time of the expected demand create the strategic need for alliances. Hoffmann (2007, p831 and p835) declares the strategy types as Shaping, Adapting and/or Stabilizing, which is Hoffmann's (2007) adaption of March's (1991): Exploration vs. Exploitation strategy theory.

An alliance is, compared to innovation, the safest and cheapest way of filling the gap as described by the contingency theory. So eventually the alliances are links between firms representing the sharing of resources and next to that it also represents the contractual commitment of two companies with each other. In Hoffmann's (2007) theory the alliances are all combined in the alliance portfolio. This portfolio combines the alliances, and all its properties. An alliance portfolio configuration consists according to Hoffmann (2007) out of: the size as in the (1) number of alliances, the structure of the alliance portfolio, determined by (2) dispersion and (3) redundancy and (4) the linkage intensity, viewed as the combined linkage strength of each individual alliance. Changing the way the alliance portfolio is configured it directly influences (1) the quality, quantity and diversity of resources, (2) the efficiency of the access and (3) the flexibility and/or stability of the firm's position (Hoffmann, 2007). Meaning the resource endowment will change, which causes the uncertainty, firm performance and shaping potential to change.

The last defining element in the theory of Hoffmann (2007) is the financial performance. In his theory he uses a net operating profit after tax (NOPAT) and return on capital employed (ROCE). The major use of the value is to perform a basic comparison which firms perform better under which condition using what kind of strategy.

In the last section of the research Hoffmann (2007) puts the proposed framework through a simple case study, with two cases. The data gathered is tested to 10 propositions, all the propositions are created out of the discussed theories and the proposed framework. The first three propositions are covering the preference of an strategy under certain types of uncertainty. The second set of three propositions is about the configuration of the alliance portfolio with certain types of strategy. The seventh and eight proposition are talking about changing strategies when the alliance portfolio configuration changes that much that the firm is not influenced by the uncertainty any more. The ninth proposition situates the influence of diminishing uncertainty on the alliance portfolio configuration. And the last proposition actually is the only proposition talking about hybrid strategies. The data for the case study came from the documentation and interview with experts of Siemens in two business units: (1) rail and transport systems and (2) fossil energy production. In the end Hoffmann (2007) concludes that the case study offer an initial empirical evidence because the propositions all hold true.

Chapter 3: Discussion of and adaptions to Hoffmann (2007)

Our view is based on the idea that every firm needs to fit its business strategy, including its resource endowment, with the industry's requirements, as supported by contingency theory (Donaldson, 2001, p8; Hofer, 1975; Wernerfelt & Karnani, 1987). To continuously create this fit in the current changing economy firms need to cooperate with other firms, in other words creating alliances. These alliances make it possible to obtain (new) resources, but also create new business opportunities (Ahuja, 2000). Based on this view, our simulation needs (1) a firm, that needs to deliver resources according to the (2) environmental requirements, and to do this it creates (3) alliances with other firms. In respect to the theory of alliance portfolio's (Hoffmann, 2007; Wassmer, 2010), firms are not able to perform basing their strategy on single dyadic relationships, but need to have an (4) alliance portfolio strategy to gather all the required resources for their fit (Figure 5).

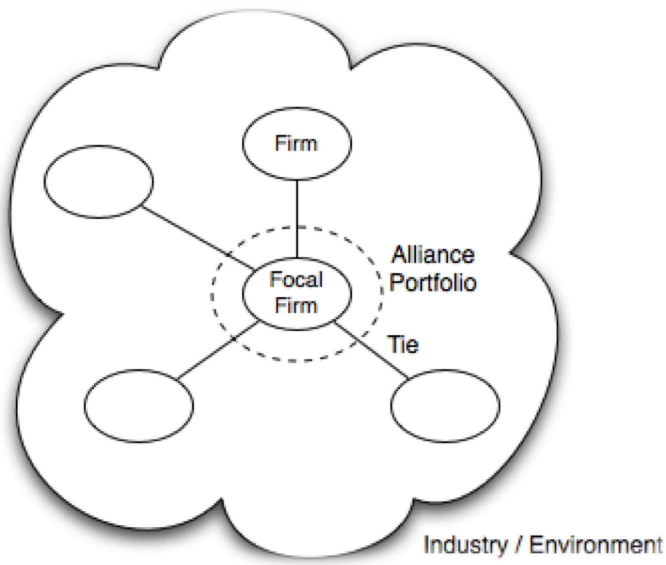

Figure 5 - Overview of an Alliance network

We share a lot of the ideas and beliefs of Hoffmann (2007), but there are some elements we interpret in a different way. In the next section we will discuss three theories used in Hoffmann (2007): (1) resource based view, (2) contingency theory and (3) strategy, and discuss a different approach on these theories. Furthermore we discuss the analytical technique (case studies) used by Hoffmann (2007).

3.1: Resource based view

Hoffmann (2007) uses the resource-based view theory of Ahuja (2000) to define three types of resources that are affected by a firm alliance activity. (1) Technical capital that represents a firm's capability to innovate. (2) Commercial capital is a firm's capability to produce and deliver to the market. (3) Social capital represents the benefits from its interorganizational relationships. One problem with the approach of Hoffmann (2007) is that he starts to use this theory to fill in the firm's shaping potential and eventually turns out to use it as the theory for the resource endowment. Using the first view the social capital is more part of the alliance strategy used by a firm; furthermore the commercial and technical capitals are part of the firm's commercial strategy to perform. We conclude that we view this division more as a division of influence on strategy than as being actual resources. Our definition for a resource-based view is based on the description of Capron et al. (1998) namely: research & development, manufacturing, marketing, managerial, and financial resources. All in all we can continue discussing this classification of resources, but main thing is that we agree on this set of actual resources to have a well-known and recognizable meaning.

Shaping Potential

Changing the resource-based view, that Hoffmann (2007) uses, creates a situation where we still need to find a way to fill in this gap in their line of reasoning, about the shaping potential. We already hinted that the explanation of Hoffmann (2007) for this approach lies more into the strategic value a firm has and how able the firm is to make changes in the firm, alliance portfolio and the industry. As we extract the three definitions form earlier of capital we find that the shaping potential is the firm's ability to innovate, produce, deliver and make changes in the alliance portfolio configuration. Continuing on page 832 Hoffmann (2007) states that acquisition and internally developing resources will take too much time and money with a too high risk in comparison to creating alliances. Therefore we will not consider internal innovation as a possible action as this is always inferior to creating alliances, leaving three possible actions for each firm: (1) produce, (2) deliver and

(3) change alliance portfolio configuration. Which are one-on-one related to the (1) technical capital, (2) commercial capital and (3) social capital.

3.2: Contingency theory

As we have pointed out explaining the contingency theory there needs to be a fit between the firm's endowment and the industry's requirements. Hoffmann (2007) uses a way of modeling the resource endowment to let the gaps in the uncertainty be filled with the corresponding endowment. By changing the resource based view we needed to find a way to explain the gap. We take a basic scheme, as presented in figure 6, where a defined number and types of resources combined creates a product that is possibly sold to an industry. So eventually the requirements of the industry influences the number of products delivered to the industry, and each product delivered to the industry will generate a financial performance for the firm.

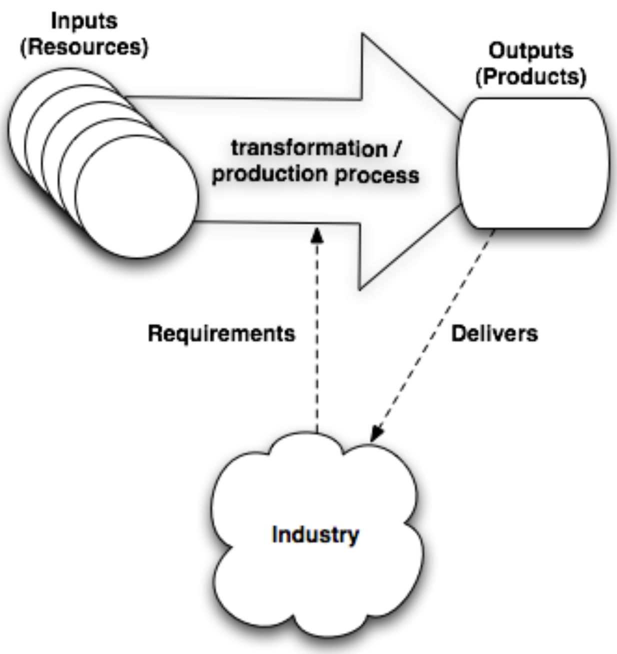

Figure 6 - Contingency theory

Looking at our interpretation of the contingency theory, as summarized in figure 6. When you take the transformation or production process out of the equation the industry requires a certain set of resources and in return the firm delivers a certain set of resources[2]. By taking this assumption we are able to link the influence of the shaping potential actions to the resource endowment and financial performance. Because in that

[2] In our research we will still use the term product to refer to this set of resources.

case we (1) produce resources, resulting in higher resource endowment, and (2) deliver resources to the industry, resulting in financial performance.

3.3: Strategy

The firm's business strategy is directly linked with the alliance strategy used (Hoffmann, 2007). The choice in strategy is namely connected to the contingency factors of the industry. One of the main inducements is the need for resources generated by the gap between the current resource endowment and the expected demand. The accuracy, flexibility and time of the expected demand create the strategic need for alliances. Hoffmann (2007, p831 and p835) declares the strategy types as Shaping, Adapting and/or Stabilizing, which is his adaption of March's (1991) Exploration vs. Exploitation. In organizational strategy theory there are a lot of approaches that are usable to categorize strategy, i.e. cost leadership and differentiation from Porter (1987) or Miles and Snow's (1978): Prospectors, Defenders, Analyzers or Reactors.

Because we have our doubts about the adaptions to the strategies of March (1991) by Hoffmann (2007), we base our strategy specification on exploration versus exploitation (March, 1991), where (1) exploration is about developing new resources and capabilities and explore new development opportunities and (2) exploitation is about using current resource endowment and wait to develop new resources.

3.4: Empirical study

One of the limitations in the Hoffmann (2007) research he admits to is that the empirical evidence created by the case study performed is too small. This causes that the framework and the combination of the theories are not supported by empirical evidence. There are two aspects that limit the case study: (1) the subjectivity of the data and (2) the amount of case studies available. Letting managers indicate all the variables on a seven-step ordinal scale creates the first limitation. The second limitation is created because firms are not transparent when it comes to alliance portfolio configuration management, as this is sensitive information. As we will show in the next phase agent-based simulation research takes subjectivity out of the equation, because each agent works autonomous but is coded to perform certain actions. The second reason why we should use agent-based simulations is that this approach creates the possibility to create an unlimited number of cases, and therefore take away the second limitation Hoffmann (2007) faced in his research.

3.4: Conclusion

By making the proposed changes to the cause-effect diagram of Hoffmann (2007) (figure 3), we propose a new model as represented in figure 6. Taking a first look at the diagram possibly gives the impression a lot has changed but actually the influence of the main aspects (bold titles) on each other did not change with the exemption of the financial performance which is not influenced by the shaping potential instead of the resource endowment and improves the resource endowment through the “produce” in the shaping potential.

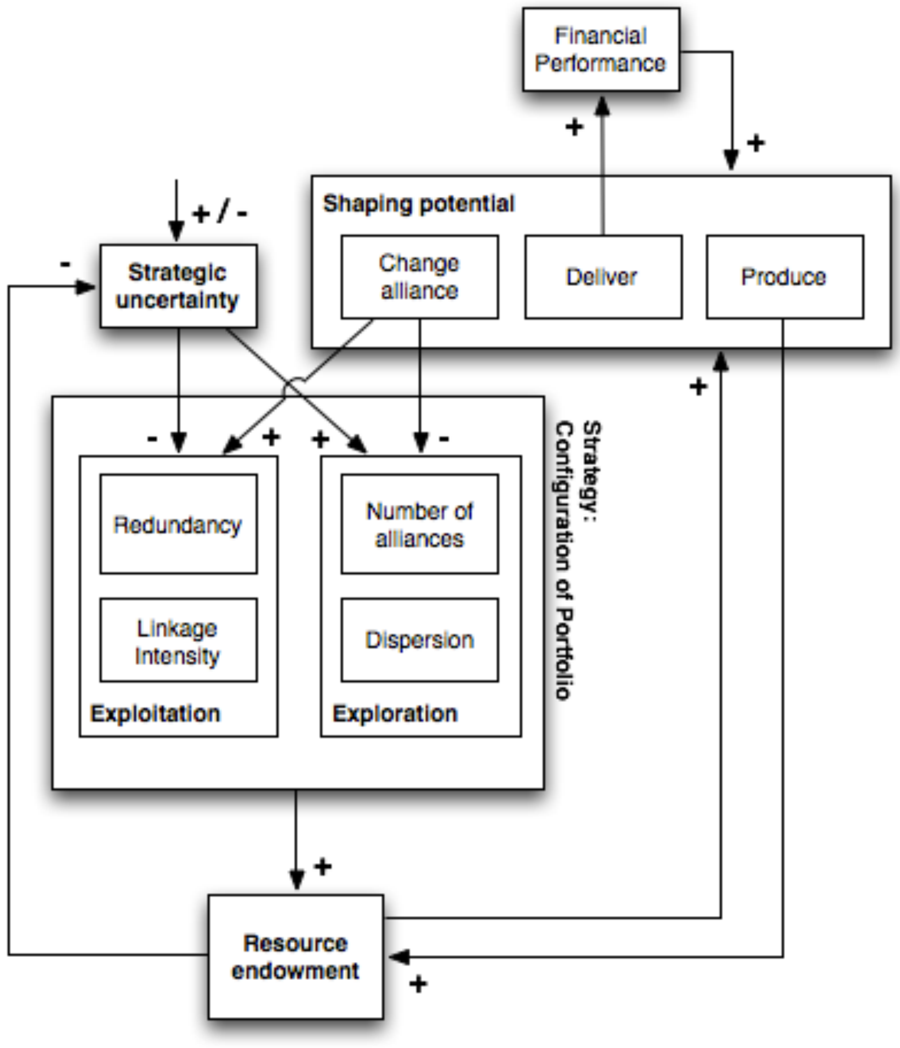

Figure 7 - Adapted cause-effect diagram

PHASE 2: SIMULATION

Simulation-based research, and with that agent based simulations, has gained recognition in the field of social science research as a significant methodological approach to produce empirical data, provide an analytically precise method to specify and explain theoretical logic, and reveal outcomes of theories, as they would develop over time (Davis et al., 2007).

Simulations enable theorists to test their theory in a computational representation. A computational model is able to surface holes in the validation elements of the theory during the design phase of a simulation, because it allows the creation of a computational model when the theory is well described and/or specified. When there are still unsolved issues in the theory it is impossible to represent the theory into a model, unless by making assumptions or simplifications, which will generate a model which is more open to discussion. Thus, every relationship to be modeled has to be specified exactly and every parameter has to be given a value, for otherwise it will be impossible to run the simulation (Gilbert, 2004). Although models are simplifications of reality it should be guided by theory rather than simplifying the theory. The major benefit using simulations is that it creates the possibility to execute a controlled "lab" experiment by using a computational representation by which researchers are able to systematically test theories without the need of testing theory directly into the "real" world. Another benefit of simulation is that, in some circumstances, it can give insights into the 'emergence' of macro level phenomena from micro level actions. For example, a simulation of interacting individuals may reveal clear patterns of influence when examined on a societal scale (Gilbert, 2004). Hence, simulation based research can be a means to further validate theory in a way that researchers are able to perform focused tests in the real world, with already having excluded or proven certain outcomes.

Various authors have stressed that simulation-based research is especially useful at stages between theory-creating and theory-testing research (Davis et al., 2007; Trochim & Davis, 1986). More specifically *"simulation enables the elaboration of rough, basic theory that is often derived from inductive cases or formal modeling into logically precise and comprehensive theory. […] Simulation is particularly useful […] when empirical data is challenging to obtain."* (Davis et al., 2007).

Chapter 4: Agent based simulations

The Multi agent systems field takes inspiration from, and in turn contributes to, a very wide range of other disciplines (i.e. artificial intelligence (AI), economics, software engineering, and social science) (Wooldridge, 2009, p. xvi). The extant literature (Do, Kolp, & Pirotte, 2003; Vidal, 2010; Wooldridge, 2009) view Multi Agent Systems (MAS) ”[…] *as a social organization of autonomous software entities (agents) that can flexibly achieve agreed-upon intentions by interacting with one another. MAS do allow dynamic and evolving structures which can change at runtime to benefit from the capabilities of new system entities or replace obsolete ones.”* (Do et al., 2003, Introduction).

Because of these properties multi agent-based simulation (MABS) are able to simulate behavior from single to grouped entities, so that they are able to simulate the behavior of individuals, teams, companies or complete markets. By using MABS we are able to create environments and agents that are able to simulate real life experiments, this enlarges the possible applications of agent-based simulations. Using MABS it is possible to carry out experiments on artificial social systems that would be quite impossible or unethical to perform on human populations (Gilbert, 2004). With these simulations managers are able to play “what-if” games with the model and can think directly in terms of familiar business processes, rather than having to translate them into equations relating observables (Van Dyke Parunak, Savit, & Riolo, 1998).

MABS research in management research has been used to model the behaviors of adaptive actors (i.e. individuals, department or firms) who make up a social system (relatively departments, firms and industries) and who influence one another through their interactions; examples include individuals interacting in an organizational system or organizations interacting in an industry (Harrison et al., 2007). These studies are in line with a lot of other studies about culture and/or demography (intra-organizational) versus organizational decisions, commonly researched in complexity theories, like (Carroll & Harrison, 1998; Davis et al., 2009). All these papers are performing research on interaction within an organizational system.

In our research we are mainly interested in how organizations interact in an industry, and we are specifically interested in collaborating organizations within an industry. Current research have applied MABS methods in inter-firm collaboration research to examine learning issues in inter-organization networks (Taylor, Levitt, & Mahalingam, 2006). In another learning alliance oriented paper from Kapmeier (2008) they give a model for a simulation (note that they didn't use agent based simulations) for the relation between opportunistic behavior and alliance dynamics. Other research has analyzed the benefits of a specific form of supply chain cooperation in different competitive scenarios and for diverse organizational structures (Albino, Carbonara, & Giannoccaro, 2007). Furthermore Ku, Kao & Gurumurthy (2007) proposes a framework to analyze and design logistical processes for mergers/acquisitions.

If we focus more on the MABS in network research, business research and alliance simulations we find some issues concerning; depth of research (individual level vs. firm level) (Panait & Luke, 2005), heterogeneity of the agents (agents working together or working "against" each other vs. a combination of these, with this also the competitiveness of the agents/teams of agents) (Horling & Lesser, 2005; Panait & Luke, 2005), number of agents used in simulations (2 to 3 vs. multi) (Berry, Hobbs, Meroney, O'Neill, & Stewart, 1999; Panait & Luke, 2005), dynamicity in the environment, teams and scenarios (Horling & Lesser, 2005; Panait & Luke, 2005).

Next to these issues we find that we had a tough time finding published material, which connects simulations to alliance literature, trying to find out why we found that according to Harrison et al. (2007) the proportion of publications in Management journals in which simulation is used in any way is very low, average of around 8%, but increasing, see figure 8. Although these numbers are low we believe that the field of management can benefit from simulation research, as described above, supported by papers of among others (Davis et al., 2007; Harrison et al., 2007; Li, Mao, Zeng, & Wang, 2008).

TABLE 1
Proportions of Simulation Articles in Social Science Journals, 1994–2003

Discipline	Journal	Proportion of Simulation Articles[a]
Management	*Academy of Management Journal*	.003
	Administrative Science Quarterly	.022
	Management Science	.236
	Organization Science	.037
	Strategic Management Journal	.010
Sociology	*American Journal of Sociology*	.024
	American Sociological Review	.024
Psychology	*Psychological Bulletin*	.034
	Psychological Review	.378
Economics	*American Economic Review*	.073
	Journal of Political Economy	.074
Political science	*American Journal of Political Science*	.065
	American Political Science Review	.047
Total		.079

[a] These numbers are ten-year averages.

Figure 8 - Table of proportions of simulation articles in Journals (1994-2003)(Harrison et al., 2007, p1232)[3]

Chapter 5: Simulation Tool Quick Search

To continue our project we need to have a simulation tool. To make a decision which tool to use we used literature reviews (Arunachalam, Zalila-Wenkstern, & Steiner, 2008; Railsback, Lytinen, & Jackson, 2006; Tobias & Hofmann, 2004). There are a lot of tools available, based on the papers we found, we decided to take a closer look at four tools: NetLogo, MASON, RePast, and Swarm. According to their research these simulation tools are the most used platforms for agent-based social simulations. To analyze the tools we used the analysis criteria as used in Tobias & Hofmann (2004), see appendix A. This

[3] Harrison, J., Lin, Z., Carroll, G., & Carley, K. 2007. Simulation modeling in organizational and management research. Academy of Management Review, 32(4): 1229.; "Table 1 shows that, in the leading management and social science journals, about 8 percent of the published papers used simulation methodology. Among leading management journals, Management Science has published a substantial proportion of simulation papers. This is somewhat misleading, however, since many of these simulations do not address social or behavioral issues. Except for Management Science, the rate for management journals is much lower, varying from 3.7 percent in Organization Science to 0.3 percent (only two papers in ten years) for the Academy of Management Journal. Among the social science journals, sociology shows a low-frequency pattern similar to management. But simulations are more prevalent in the other social science disciplines, led by psychology's Psychological Review, where, in some years, more than half of the articles were simulation papers. The results for economics may actually understate the use of simulation in this field, since these journals typically publish more papers; for the ten-year period we examined, the American Economic Review published 118 simulation papers."

research unfortunately is limited to Java developed tools, therefore NetLogo and MASON are not tested in this research. We therefore copied the values for Repeat and Swarm and added the values for NetLogo and MASON. The bases for grading the different criteria are: (1) the three review papers, (2) the documentation provided with the tools and (3) our own experience through testing and "playing" with demos, resulting in table 1.

Table 1 - Simulation tool comparison

	NetLogo	MASON	Repast	Swarm
General criteria	**26**	**21**	**27**	**25**
License	4	4	6	5
Documentation	6	4	6	6
Support	5	3	5	3
User base	6	5	5	6
Future viability	5	5	5	5
Modeling and Experimentation Criteria	**25**	**17**	**24**	**19**
Support for modeling	3	2	3	3
Support for simulation control	5	4	5	5
Support for experimentation	2	2	3	3
Support for project organization	2	2	1	1
Ease of use	4	2	3	2
Support for communication	3	3	3	1
Ease of installation	6	2	6	4
Modeling Options Criteria	**31**	**26**	**30**	**27**
Large number of complex agents	5	6	5	6
Inter-agent communication	4	5	4	4
Nesting of agents	1	1	6	6
Generating agent populations	4	3	3	3
Generating networks	6	2	4	2
Management of spatial arrangements	5	5	4	2
Dynamically changing the model structure	6	4	4	4
TOTAL	**82**	**64**	**81**	**71**

The evaluation of these scores does not take into account the relevance and significance of each of the criteria. We therefore weigh every criterion and use this value to create a weighted total score. We base our weight value on the same system as Tobias & Hofmann (2004) as their weighting scheme is summarized by: "criteria that spare the user a lot of effort (work and time) should be weighed higher than those that represent only little savings in effort." (Tobias & Hofmann, 2004, point 5.4). We adapted some of the weights to ensure that the tool would be as easy and quickly to use as possible, based on our skills. Resulting in table 2.

Table 2 - Weighted Simulation tool comparison

	Weight	NetLogo	MASON	Repast	Swarm
General criteria		**85**	**63**	**89**	**80**
License	3	12	12	18	15
Documentation	6	36	24	36	36
Support	4	20	12	20	12
User base	2	12	10	10	12
Future viability	1	5	5	5	5
Modeling and Experimentation Criteria		**111**	**66**	**108**	**86**
Support for modeling	5	15	10	15	15
Support for simulation control	4	20	16	20	20
Support for experimentation	4	8	8	12	12
Support for project organization	1	2	2	1	1
Ease of use	6	24	12	18	12
Support for communication	2	6	6	6	2
Ease of installation	6	36	12	36	24
Modeling Options Criteria		**132**	**108**	**112**	**100**
Large number of complex agents	6	30	36	30	36
Inter-agent communication	4	16	20	16	16
Nesting of agents	1	1	1	6	6
Generating agent populations	4	16	12	12	12
Generating networks	6	36	12	24	12
Management of spatial arrangements	3	15	15	12	6
Dynamically changing the model structure	3	18	12	12	12
TOTAL		**328**	**237**	**309**	**266**

Comparing our findings we concluded that NetLogo is a light tool, as it does not take a lot of memory nor too much time and speed to perform and it has enough possibilities for distributing the tool. Next to this it can do all the things we need without having to find the right extensions and additional learning, especially these conditions are problems we expect with the other tools. Although NetLogo might not give us the low-level platform we might need to attract the full potential of our research, it is “strongly recommended for prototyping models that may later be implemented in lower-level platforms: starting to build a model in NetLogo can be a quick and thorough way to explore design decisions” (Railsback et al., 2006). Concluding; we decided to use NetLogo as our simulation tool.

Chapter 6: NetLogo[4]

As we decided to use this tool based on our quick search, in this chapter we explain how to use NetLogo to design and program an agent based simulation. We will not go into the actual use of the elements in the interface and how to do the programming as the user manual[5] contains a very easy to understand manual to explain these elements.

NetLogo is a tool that is a development out of StarLogoT by the CCL under authoring of Uri Wilensky. The main purpose of the tool is to provide a programmable modeling environment for simulating natural and social behavior. One of the main advantages of this tool is that it is able to simulate a lot of agents while still being able to view micro patterns (individual agent behavior) and macro patterns (interaction between agents). This visual aspect makes the tool very useful for “nontechnical” users, in the sense of users that don’t have a programming background. For developers it is nice to know that there is an extensive community using the tool. Furthermore it has extensive documentation and tutorials by which even the “nontechnical” users would be able to develop a small simulation, for example in courses.

6.1: Structure

We will first explain something about the overall structure of the NetLogo tool before we go into details about the theoretical background and the methods of designing and programming simulations. Every simulation tool has it’s own naming for basic elements in a MABS tool, table 3, gives an overview of the terminology used in NetLogo for the different concepts.

Table 3 - Terminology of agent based simulation concepts

Concepts[6]	**NetLogo**
Object that builds and controls simulation objects	Observer
Object that build and controls screen graphics	Interface / World
Object that represents space and agent locations	Patch / World
Graphical display of spatial information	View
User-opened display of an agent’s state	Monitor
An agent behavior or event to be executed	Procedure
Queue of events executed repeatedly	“go” Procedure

[4] All references to NetLogo are a reference to the tool NetLogo (Wilensky, U. 1999. NetLogo (http://ccl.northwestern.edu/netlogo/) Northwestern University. Evanston, IL: Center for Connected Learning and Computer-Based Modeling.)

[5] http://ccl.northwestern.edu/netlogo/docs/ or “NetLogo User Manual” under the help tab in the program

[6] Concepts coming from table 2 in Railsback, S. F., Lytinen, S. L., & Jackson, S. K. 2006. Agent-based Simulation Platforms: Review and Development Recommendations. ***SIMULATION***, 82(9): 609-623.

NetLogo is based on agents that are able to move around in a certain area; they call agents turtles that move around patches in the (so called) world. This movement of an agent is used to describe the basic action an agent is able to perform (Vidal, 2010; Wooldridge, 2009). NetLogo eventually extended this view with links, to connect agents for the purpose of making networks, graphs and aggregates. To make the simulation have some sort of overall guidance for the whole environment (called world in NetLogo) they included the observer. So summarized all the main elements of the NetLogo environment are; (1) observer, (2) world containing patches, (3) turtles (/agents) and (4) links.

Next to the elemental structure of the NetLogo simulation tool we also have an interface structure of the NetLogo tool. The NetLogo consists out of a graphical interface, documentation ("information") interface and a programming ("procedures") interface. In the graphical interface users are able to execute the simulation and follow the changes in the environment, by looking at the real-time representation of the environment and by different programmed monitors/plots. The other purpose of this interface is to guide the first design steps as it includes the option of adding the (user changeable) variables and the variables that you want to follow, via monitors and plots, to the simulation. The information interface is actually nothing more than a textual interface, where the developer of a simulation can write the purpose and manual for the simulation. The last interface, the procedures interface, is the part where developers can specify the behavior (beliefs, actions and plans) and appearance of the agents, patches and links. The procedures interface is also the place where the programmer can specify the schedule or steps in a special "go" procedure.

6.2: Theoretical Background

There are two areas to review agent based computing; (1) the micro level that covers the agent design and (2) the macro level that concerns the society/interaction design. We will use both views to review how the NetLogo tool incorporates these ideas.

Micro Level – Agent design

The NetLogo Logo based programming language includes many high-level structures and primitives that greatly reduce programming effort. On an agent level of view we first need to know something about how the belief, events and plans (Do et al., 2003) are situated in the NetLogo tool. The observer generally triggers the events of agents by asking the agent(s) to perform a certain (group of) action, as specified in the written procedures.

Beliefs are coped with by letting agents make decisions influenced by the value of the (self-declared) attributes it carries. The plans are as with the beliefs also part of the coded procedure functions.

Another part of agent theory is the aspect of having autonomous agents, are they able to perform actions on themselves without being connected to the environment or other agents. NetLogo provides autonomy through never letting other agents carry information of other agents. Agents are however able to "ask" other agents for their information. So the autonomy of the agents is still part of the task of a developer to make the agents as independent as possible.

Macro Level – Society/Interaction design

At a macro level we are interested in the communication ability between agents. Parts of the communication aspect are (1) cooperation, (2) coordination and synchronization and (3) negotiation. This is actually covered in a rather easy way; by the "ask" function. The entities are able to ask each other to perform an action or retrieve information the other entities own. So exchanging variables between elements (and performing actions on them) covers the communication. Concluding there is not a complicated communication scheme, although there is the possibility for the developer to refrain entities of talking to each other.

Chapter 7: Simulation Design

Hoffmann (2007) uses a empirical test technique (case study). Using an agent-based simulation we are able to improve the empirical value of our proposed model. The cause-effect method as used by Hoffmann (2007) creates causal loops, following these loops makes the first couple of propositions true, furthermore the empirical study performed is lacking (see Chapter 3). We question if the propositions are still true if we recreate the empirical research using our agent-based simulation, and test the propositions over a multiplicity of cases. This is in line with the methodology as proposed by Davis et al. (2007) where they describe to start off with a defined theory and improve the theory using a simulation to simulate more cases.

In chapter 2 and 3 we explained the way we interpreted the theory of Hoffmann (2007) based on our view, using our understanding of the theory and without the limitation of the NetLogo simulation environment. We start our design using our understanding of the actors, as presented in figure 5, by creating a simple class diagram, see figure 9. In this diagram it is made clear that each firm is only active in one industry and that firms can have multiple relationships with other firms, where this relationship is the alliance.

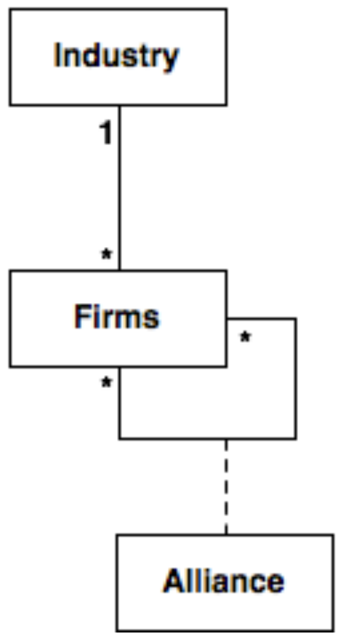

Figure 9 – Simple Class Diagram

In our proposed theory as explained in figure 7, we visualized the influence of certain elements inside a firm. We recognize the following elements that need to be included at the firm's entity in our design; (1) strategic uncertainty, (2) strategy, (3) configuration of portfolio, (4) resource endowment, (5) shipping potential, and (6) financial performance. Some of these elements are influencing other entities; the clearest element, is the influence of an external entity strategic uncertainty, represented in figure 7 by the arrow coming from the outside, on the. i.e. industry and/or the environment. To clarify these issues we will explain the design of each element and if necessary explain the relation to other entities. In the last part we will discuss the way we design the alliance.

7.1: Strategic Uncertainty

Uncertainty is the main aspect in creating a dynamic situation. In our theory we assumed that the strategic uncertainty of the firm is the subjective perceived environmental uncertainty. In our case we cannot design a perceived value for strategic uncertainty, as we are not able to simulate this value, so we need to have certain variables and actions that simulate the strategic uncertainty. We do need to keep in mind that eventually we want to test the performance of a firm's alliance configuration strategy in changing environment, so we should focus on the uncertainties that change the environment. Looking at Wernerfelt & Karnani (1987), we could have four kinds of competitive uncertainty;

- Demand uncertainty; are fluctuations in demand for certain end products. Based on our contingency theory this means that the requirements from the industry for a certain set of resources will change.
- Supply uncertainty; is an uncertainty that you need to have a certain kind of evolvement of resources to be able to improve certain products. So these are actually limitations to your production process, i.e. machines shutting down, research of new production methods. This uncertainty is more a uncertainty inside a firm as we are focusing on the uncertainties coming from the environment rather than the inside uncertainties we do not consider this uncertainty for our simulation.
- Competitive uncertainty; is a combination of things that influence the position of the firm in the market, examples of events that could change the position are changing or failing alliances, new firms entering the market and firms going bankrupt. We included the option to simulate all these kinds of uncertainty.
- Externalities / Regulative uncertainty; is an uncertainty based on rules set by the industry or country the industry is part of, i.e. trade regulations, production laws, pollution regulations, etc. Based on our decision to let all the firms act in the same industry we do not think this uncertainty is useful for our simulation.

We decided to include two types of uncertainties; (1) demand uncertainty, and (2) competitive uncertainty. Demand uncertainty is clearly part of the *industry's actions* to change the requirements of the industry. The competitive uncertainty is a bit more difficult because the option of new entries to the industry and declaring firms bankrupt (deleting firms) are *actions of an external actor,* in our case the world. In case of the changing and failing alliances out of competitive uncertainty we came up with the idea of having an alliance contract time, in which it creates a competitive uncertainty through terminating alliances based on time and not just when one of the firms is unable to comply to the terms anymore.

Concluding, the entity industry will have an action to change the requirements of the industry and the environment will have actions to add and remove firms, and remove alliances based on the contract time variable in the entity alliance.

7.2: Strategy

The next element we look at is the *strategy*. Based on our proposed theory; firms use two strategies: (1) exploitation or (2) exploration. As shown in figure 7; exploitation influences the firm's alliance portfolio configuration by having a preference for high redundant and strong alliances, while exploration forces a company to rather have a lot of alliances and with a high dispersion. In this case the strategy is a variable influencing the change alliance action of the shaping potential. Based on the linkage between alliance portfolio configuration strategy and business strategy, the influence of the strategy on the alliance portfolio configuration the firm's strategy also has influence on the business strategy. Meaning that firms using an exploitation strategy will focus on generating as much of a certain product as possible. The exploration strategy will be based on generating as much different products as resources allow. So the strategy is also influencing the shaping potential's delivering to the industry.

7.3: Configuration of portfolio

The configuration of the alliance portfolio is based on four elements: (1) Size; measured by the number of alliances, represented by the number of alliance ties or relationships between firms. (2) Linkage intensity, measured by the strength of each of the alliances. Linkage strength is a value for the trust between the two firms part of the alliance. This value could be based on the time, depth and/or breadth of the exchange of resources in the alliance. We choose to use the give the linkage strength a value of time. (3) Redundancy, this is measured by depth of the content from all the alliances combined; when there are a lot of alliances that exchange the same type of content the redundancy is high. In our case we share resources over the alliance. When the amount of a certain type of resource is high the redundancy will be high. (4) Dispersion, this is measured by spread of the content from all the alliances combined; If there are a lot of different resources shared over the alliances the dispersion is high, if there are a lot of alliances sharing the same type of resources the dispersion is low.

So all of these elements are a summarization of the firm's alliances and its content. To make this measurable each alliance relationship needs to have a variable: strength, through "time active", and a variable: content, containing the shared resources.

An advantage of the linkage strength is that the costs to change an alliance are less when the alliance would exist for a longer period of time. In our simulation we compare the linkage strength of the alliance with the rest of the alliances. When an alliance exists longer than average the costs are less than the regular changing costs and when the alliance exists shorter than average the costs are higher than the regular changing costs.

7.4: Resource endowment

As explained in our contingency theory resource endowment is closely linked to the different shaping potential actions. The main purpose of the resource endowment is the firm's ability to deliver products to the market. What we want to know is what (and how many) resources the firm has available. To do so the firm needs to combine all the resources it already has produced or in storage and the total sum of resources it gets from being involved into alliances, meaning the content of the alliance. So the resource endowment is the list of resources available in the firm, which is a combination of the current stored resources and the combination of all shared resources in the alliances. The shared resources are send to the firms by their partners at the beginning of each turn, at least before the production has started, this is to ensure that the firms always do their best to deliver as agreed in the alliance contract. If a firm is not able to deliver due to a lack of resources, it will terminate the alliance.

7.5: Shaping potential

In this section we will explain each action a firm can perform. As discussed in Chapter 3 a firm has three possible actions to perform: (1) produce, (2) deliver and (3) change alliance portfolio configuration.

Produce

There is the possibility that to perform an action additional variables are necessary. The first action is *to produce*; we view this action as the production of resources by the firm. The resources a firm is able to produce are saved within the resource endowment variable.

So to keep track of the total amount of resources the firm currently has we need to have some sort of storage variable. The only thing this variable does is that it constantly keeps track of all the resources the firm has access to.

Deliver

In the action *to deliver* we incorporated our changed understanding of a production process (as described in the part about the combination of the product entity into the entity relationship diagram) and deliver a certain amount of resources based on the requirements of the industry to gather performance value for those products. The decision of which product to deliver is based on the strategy of the firm, see the part about the strategy for an explanation. All the resources delivered are subtracted out of the total resources variable and for each product it delivers it adds the value of the product to the performance value of the firm.

To decide what to deliver to the industry and for searching the favorite product the firm uses methods of comparing resources and requirements as explained in the description of resource endowment. In case of exploration the firm tries to find a wide spread of products and in exploitation the firm tries to minimize the spread and maximize the quantity. So in exploitation the firm will search the possibility to produce as much of one product as possible, and for the favorite product it rather searches for resources to create more of the product it already creates most of at the moment. In exploration the firm will try to create one of each product (starting with the highest value towards lowest value) and tries to do this as many times as possible. In searching for the favorite product it takes the resources it needs to create more of the product it currently creates the least of. So the favorite product creates the demand for a certain amount and type of resources.

Facing a method to compare resources we faced with an issue about the way we view how firms endow resources, and how this is translated into performing and delivering to the market. Eventually we found a solution in the approach of Grant & Baden-Fuller (2005), although they apply their approach to knowledge utilization, the way of using matrices to see what products to produce and what knowledge is unused and possibly exported or what knowledge imported to develop the products is very useful. We use the same idea in our situation; starting off we want to know what (and how many) resources the firm has available. We elaborated on our theory of having a certain set of resources, and compared to Grant & Baden-Fuller (2005), we only use 5 types where they use 18 types of knowledge. We decided to go for a scalable situation that is able to represent the extensive wishes of the industry by creating subtypes of the resources. You can imagine that in reality that i.e. managing can have different styles and each style will influence the end product in it's own way, like the management style to use just-in-time create more specific products than a mass production management style. So in this case each main category can have it's own subtype. To produce a product you need to have a certain mix of specific resources to create a product. For the ease of explaining we won't get into having a certain amount of resources of a certain type but only cover the availability. In our examples a "X" means that the resource is available or that availability is needed to create the product and deliver it to the industry.

Table 4 – Resource Endowment Example – Firm's resources endowment table combined with all alliance's shared resources table

Resource types = 3	RD Type 1	RD Type 2	RD Type 3	MAN Type 1	MAN Type 2	MAN Type 3	MRK Type 1	MRK Type 2	MRK Type 3	MNG Type 1	MNG Type 2	MNG Type 3	FIN Type 1	FIN Type 2	FIN Type 3
Firm A	X		X	X	X	X	X			X	X		X		X

In Table 4 an example of a table of the Firm's resource endowment is given. The easiest way to combine the firm's resource endowment with the shared resources from the alliances is if both the firm's resources endowment table and the Alliance's shared resources table would have the same dimensions. This just means that both should have the same dimensions, namely the resources as length and the availability (or amount) as the attributes. Table 5 gives an example of the resources requirements matrix of an industry containing a matrix with the resources required to produce certain products in that industry.

Table 5 - Resource endowment Example – Industry Requirements table

Resource-types = 3, Products = 5	RD Type 1	RD Type 2	RD Type 3	MAN Type 1	MAN Type 2	MAN Type 3	MRK Type 1	MRK Type 2	MRK Type 3	MNG Type 1	MNG Type 2	MNG Type 3	FIN Type 1	FIN Type 2	FIN Type 3
Product 1	X				X	X	X			X	X		X		X
Product 2		X	X	X			X	X		X	X			X	
Product 3	X	X		X		X			X	X		X		X	
Product 4	X	X	X		X			X	X		X				X
Product 5		X	X		X	X	X		X			X	X		X

We can now use these tables to compare the firm's resource availability table with the industry's requirements table. The highlighted columns are the firm's resource endowment (figure 4), if we lay this over the industry's requirements (figure 5) we are able to see which product(s) the firm is able to produce. We made an example of this comparison in Table 6. In our example we can produce and deliver product 1, but we are missing resources to produce the rest of the products. So if we also want to be able to make product 2 we need to find an alliance to get RD Type 2, MRK Type 2 and FIN Type 2 out of. As we can see we have an excess of MRK Type 3 so that would be our resource that we can offer to the alliance partner.

Table 6 - Resource Endowment Example - Comparison table

Resource-types = 3, Products = 5	RD Type 1	RD Type 2	RD Type 3	MAN Type 1	MAN Type 2	MAN Type 3	MRK Type 1	MRK Type 2	MRK Type 3	MNG Type 1	MNG Type 2	MNG Type 3	FIN Type 1	FIN Type 2	FIN Type 3
Product 1	X				X	X	X			X	X		X		X
Product 2		X	X	X			X	X		X	X			X	
Product 3	X	X		X		X			X	X		X		X	
Product 4	X	X	X		X			X	X		X				X
Product 5		X	X		X	X	X		X			X	X		X

Change alliance portfolio

We now come towards the important part of the simulation, creating and changing the alliance portfolio. There are three actions possible on an alliance; *add, change and terminate.* For a firm to add an alliance it needs to know what partner it wants to make an alliance with. This is based on two things: (1) the preference for certain resources based on the strategy of the firm and (2) (a multiplicity of) the amount of resources a partner is able to give back, because when the amount gained from an alliance is not equal to the amount given back the alliance need to find a way to equally distribute the income gathered from having the alliance. Whenever the preferred alliance partner is already in the alliance portfolio it will make changes to the alliance, meaning that it will change the resources shared in an alliance. Whenever one of the firms in an alliance is not able to deliver the amount of resources agreed on in the alliance contract, the alliance is terminated.

So for a firm to execute the add or change alliance action it should also have a search action to find a suitable partner. In the alliance partner search the firm searches for a best-fit situation. To be able to create this fit a firm needs to know what it is able to offer in an alliance. After delivering all the products we assume that all the resources the firm hasn't used at that point are available to create alliances with.

The strategy influences the search for partners as well; where in the exploitation the firm searches all the partners in the current alliance portfolio first, based on figure 6 that shows a preference for redundancy and intensity, if it finds a partner with a success rate (percentage of covering the demanded resources) above a certain value it goes for that partner. Otherwise the firm will search all the firms it currently doesn't have an alliance with, and will compare the best finding with the finding of the last search and takes the one with the highest success rate. With the exploration this is the direct opposite; it starts with all the firms it doesn't have an alliance with and if the success rate doesn't meet the threshold it searches all the firms it currently has an alliance with and chooses the highest success rate.

7.6: Financial Performance

The performance indicator for a firm is represented by the financial performance. In Hoffmann (2007) the measurement for this performance is: Net operating profit after taxes (NOPAT) and return on capital employed (ROCE). The main reason why they use this financial performance is to indicate the firm's competitive position. In our case we see the financial performance as the direct performance indicator to measure how successful a firm is. Financial performance is influenced by the shaping potentials action to deliver products, as explained in our contingency theory. Whenever a firm delivers a product to the industry it will receive the value of that product in return. The same as you would expect in the real world where customers pay with money to buy a certain product.

This however could create an infinitive growth in the financial performance. To counter this effect we need to think about *capacity or time constraints*. By which the financial situation creates a constraint for the firm, as it is only able to perform a certain amount of actions during a certain amount of time. Or when the firm is constraint by money it is only able to pay for a certain amount of workforce to produce a certain amount of products. So we will need to let the actions performed out of a shaping potential perspective influence the financial performance as it would in real life as well. The delivery will have a positive influence on the performance where a change in alliance portfolio and the production will have a negative influence on the performance.

7.7: Conclusion

Combining all the discussion we generated a detailed diagram containing all the variables and actions according to our theory for each entity (figure 10). In the diagram we use a tree like notation so that for each element it is clear from which main element it is derived, i.e. time active, is part of the strength, which is part of the linkage intensity as discussed in the alliance portfolio configuration. This way you are able to look back in this chapter to see the explanation why it is part of that entity.

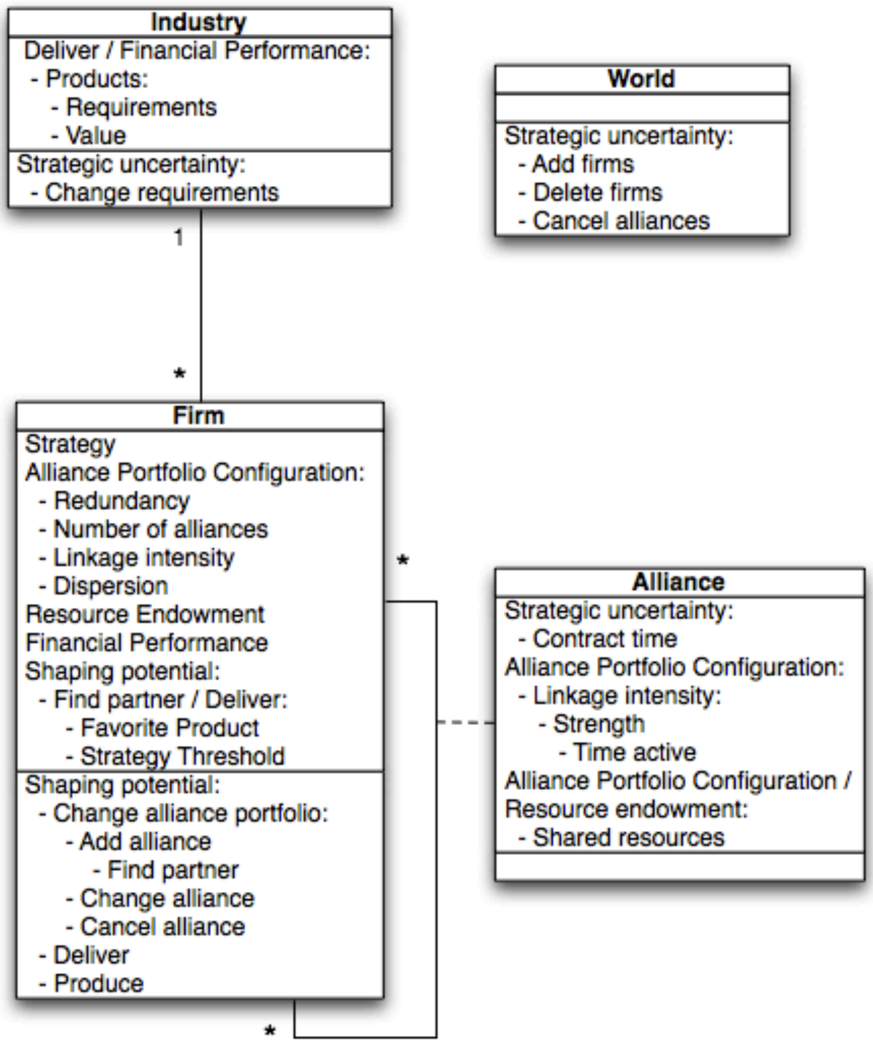

Figure 10 – Extensive Class Diagram

Chapter 8: Translating Design to Simulation

We completed the theoretical design, by defining the diagram. To make the design workable in the NetLogo environment we need to give each element in this design a more specific meaning. So we will start by defining the values for the variables and describing how actions are influencing the variables, other actions and other entities, in 8.1. After that we use all previous design elements to generate our simulation, in 8.2.

8.1: Quantification of the variables and functions

Now that we have a detailed diagram that we are able to map onto the NetLogo entities we will find explanations for the variables and functions of the entities. It is possible that via the explanation of a variable or action we need to change the class diagram. The mapping of entity relationship diagram onto the NetLogo entities is quite straightforward (1) the firms will be represented as agents or in NetLogo terminology turtles, (2) the alliances will be represented by links (3) the industry will be patches and (4) the world becomes the observer. We will shortly discuss each entity in the same order as above and the variables from top to bottom as presented in the diagram. Where each entity is explained as to which role it has in the simulation and next what values the (dependent and independent) variables will have in the simulation.

Firm

Most intuitively agents will represent the firms. Based on agent-based simulation theory, an agent cannot differ in characteristics, except when there are different categories of agents (Wooldridge, 2009; Wooldridge & Jennings, 1995). In our case all firms are performing in the same industry, as thus we do not differ between focal firm and any other firm based on characteristics. Of course the value of the characteristics can vary per firm. A firm always has a identical order in the actions it performs: (1) produce, (2) exchange alliance resources, (3) deliver, and (4) change alliance portfolio configuration. We chose this order with the idea that the main goal for firms is to perform. To perform the firm needs its resources, step 1 and 2. Then step 3 is the step where the performance is created. Next the firm will search for options to improve the performance step in the future, by adapting their alliance portfolio.

<u>Strategy</u>

Strategy is an independent variable, used in the deliver and change alliance portfolio configuration actions. Each firm can have an option to have one of the two strategies, exploration or exploitation. The way this is divided is based on a variable that is changeable so that we can figure out running the simulation to create the best workable situation. Where the slider will have a range from 0% to 100%, where 0% is all agents use exploitation and 100% is all agents use exploration.

Alliance portfolio configuration

The next elements in our list are the Alliance Portfolio Configuration variables. These variables are dependent and calculated out of the composition of the combination of (the content of) all the alliances with the firm. The size is the number of alliances a firm has, the dispersion is the spread of resources shared over all the alliances combined, the redundancy is the depth of the resources shared over all the alliances combined, and the strength is the sum of the strengths of all alliances.

Resource endowment

As we already discussed in the delivery part of the previous chapter the resource endowment will become a list where the amount of items in the list is equal to all the possible resources available. In the beginning the firm will be given a base set of resources, we will be able to vary this in the user interface (UI) through a slider, therefore this becomes an independent variable. The value for each element in the list will be a random number based on the variable.

Resource endowment is also used in the action produce where this first list is the basis for what a firm is able to produce when performing the action produce. To support this the firm needs to have 2 variables one that is the resource production list, the resource endowment, and one, the firm's total resources, that contains all the resources of the firm including those coming from the alliances, which you can see as the firm's stock or storage.

Financial Performance

For the performance indicator, therefore dependent variable, we will not specify which kind of specific measurement we take, as it does not matter to us whether it is money, time, goodwill or something like that. We will let the performance start with a value of 0.

The performance is influenced by each action, as discussed before. We can use techniques used in strategy games, like civilization, when a character is moving it is only able to move a fixed amount of fields based on the character's characteristics. We can use the same technique in our simulation where a firm is only able to spend a certain amount of "performance points" on certain things, i.e. we give each firm 100 points and delivering to the market will take 30 points to complete, producing resources yourself which adds resources to the resource endowment costs 20 points etc.

We will make these costs variable and changeable so that we can figure out running the simulation what the best workable situation is. In our understanding the values for these variables will only influence the spread on the performance view. What we do know is that according to our theory the creation of resources should be more expensive than the creation of alliances. Assuming that the strength of an existing alliance influences the costs; changing an alliance will be less expensive than creating the alliance. So the division from low to high should be: (1) deliver, (2) change alliance, (3) create alliance, (4) produce. We will use the performance to keep track of this capacity. We also use this value to decide, that when the performance value drops below a certain point a certain firms goes bankrupt, and dies/vanishes in the simulation (performance-die-point), and of course with it all the alliances it was involved in.

Industry

The first aspect in case of the industry entity is how we cover this with the patches in NetLogo. We came up with a solution where each industry will has its own cluster of patches. Each industry, cluster of patches, has its own color. Eventually we decided that for our simulation it is not important to test multiple industries and the interconnection between those. Therefore the option is still available in our simulation but it does not influence the simulation by any means.

As part of the uncertainty one action is performed by the industry; *change product* each # steps, meaning that the industry will change the requirements and/or the value of a certain product at each selected step. So the world will always ask the industry to check for this before asking the firms to perform their steps.

<u>**Product Requirements and Product Value**</u>

As touched upon in the firm's action deliver, the firm receives a certain value for delivering a certain product (combination of resources). The product's value is stored in a list by each industry. The other thing we already explained is the use of the resource requirements into a table where all requirements for all products are saved.

Alliance

In our design we had a couple of options how to design the alliance in the simulation one of the most realistic options is to form an alliance where the alliance will form a new type of firm, which has its own goals and gets its resources from the other firms. This option was disregarded based on the predicted complexity this would create, by exponentially expanding the environment with firms. So we finally came up with 3 options that would only influence the way firms are linked:

1. 1 undirected link between 2 firms, which contains all the resources shared over the link to each side, so 2 variables on containing the resources for one partner and the other for the other partner.
2. 2 directed links between 2 firms, which per link contains the resources shared to the other partner.
3. A lot of directed links between 2 firms, where each new alliance, meaning every time there is a new reason to share resources. The simulation creates a new alliance that contains the resources for the direction the link had.

The first option is the least preferable because it doesn't sufficiently represent reality. The third option is the most real-life option. There could be a multiplicity of alliances between firms, where every alliance can have its own contract and reason to work together. While the third option stores the reason why a link was created, it also creates the problem that we could create an overflow of links in the simulation, causing the simulation to fail or slow down that much it won't execute anymore. So the second option was the option we choose, to develop our simulation with.

Another problem we faced was the division of performance gained out of an alliance. In a lot of cases about knowledge alliances they face the problem that you need to find an equal division based on the economic gains from an alliance (Ku et al., 2007; Mowery et al., 1996). In our case we let the firms try to create alliances where both parties share the same amount of resources, and in that case are equal contributors to the alliance. If there is an inequality in the shared resources, the firm that is contributing less resources pays a certain amount per resource it shares less, we called this the "alliance-inequality-costs". This way the firms are compensated for their higher contribution to the alliance. If at a certain point the firm is not able to pay the compensation (because it has insufficient performance points to pay the costs), the alliance will be disbanded, and will die.

While developing the simulation we came up with an extension to our alliance design proposal to include a contract time, which was needed to save the contract time and the shared resources per reason. Which ended up that the resources shared variable was changed so that it contained the resources shared, the creation time and the contract time per reason, where the reasons equaled the favorite product. So as discussed the creation variable was combined with the resources shared and contract time variable into a new variable resources per reason variable. The resources per reason contain a list of lists with a length of the possible products to be developed; each sub-list contains the creation time, the contract time and the resources shared. So if two firms create an alliance because Firm1 had Product1 as its favorite product, then at the position of product1 in the list the alliance contains the values for this alliance. The same works for other firms and other products. If two firms are working together on more than one product it is possible that one of the "sub-alliances" ends, because of the contract time, but the "main alliance" would still exist. Be aware that the time the "main alliance" exists is the bases for the linkage strength. Therefore the design will change a little because there is only one variable; "contract and resources" that contains the contract time and the resources shared per product.

Contract and resources

This variable consists out of a nested list containing the following elements per product:

1. The time (step) there was an alliance formed because of this product. If there is no alliance because of this product the value will be 0.
2. The contract time set for the alliance based on this product. This contract time is based on a variable set through a slider in the UI, where there is also an option in the UI to have all alliances have the same contract time or that it is a random value based on the UI variable.
3. The resources shared for this product over this alliance. This is represented by a list as explained in the previous chapter in the part about the deliver action. If there is no alliance based on this product the list containing the resources contains all zeros.

This variable will be used by the world to check the alliances contracts. And the firms will use this to exchange the appropriate amount of resources to each other.

Time active

The dependent variable is actually a step counter starting from the first creation at 0 of the alliance added by 1 with each step after that creation.

World

The world has the responsibility to setup the simulation environment as well as take control over the steps the simulation will take. Each step starts with checking if the uncertainty actions need to be performed; (1) add a new firm, (2) let partners terminate an alliance because the contract between both partners has expired, (3) delete a firm (and terminate all the connecting alliances) that has gone bankrupt. After it has checked upon the global constraints it will let the industry perform its possible actions and after that it will ask the firms at random order to perform their actions.

8.2: Creating the simulation

Using the diagrams and the descriptions from the previous chapters we created our simulation. A caption of the interface is shown in Figure 11, and in larger detail in Appendix C. As you can see there are a lot of sliders in the interface (on the left) so it means we have a lot of variables we can change. In the middle there are the buttons to control the simulation with and is the visual representation of the current situation of the total simulation environment. On the right there are diagrams and monitors that are keeping track of some global data during the simulation. The extensive explanation of our simulation is included in Appendix B: Simulation Design Documentation.

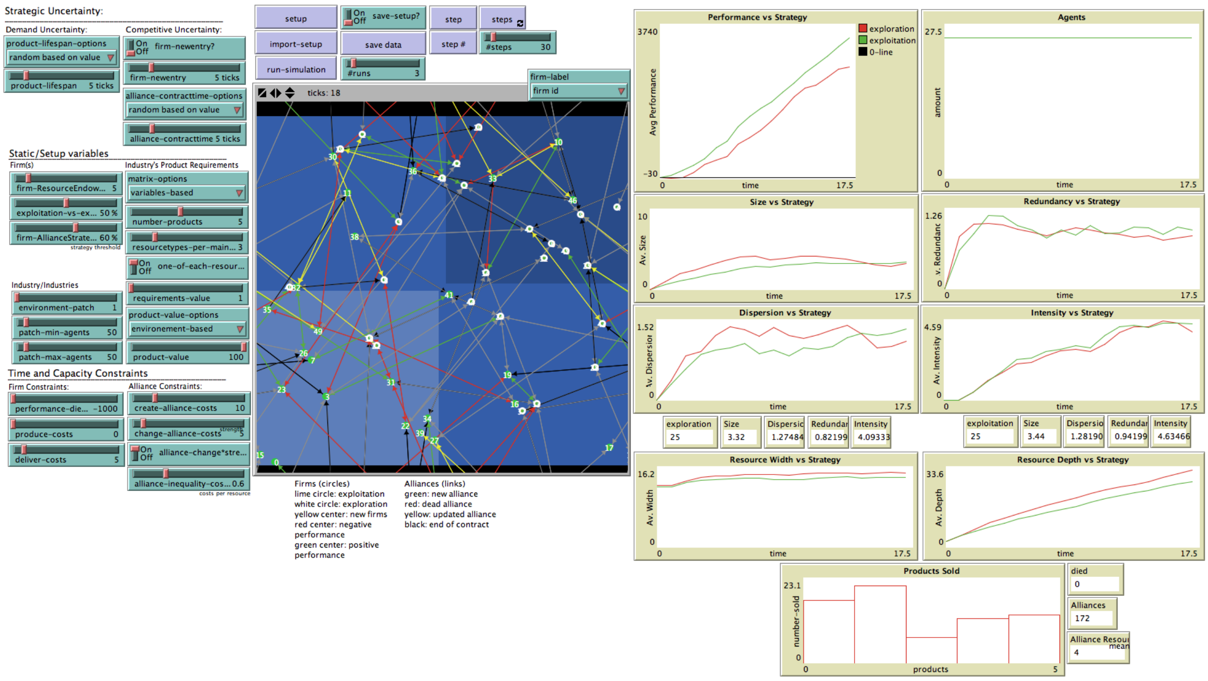

Figure 11 - Interface caption

PHASE 3: EXECUTION AND INTERPRETATION

Now that we have the simulation ready for use we are going to test the adapted Hoffman theory. To do this we first need to create Test Cases based on Hoffmann's propositions. After performing these tests we are able to analyze and evaluate the data that will serve as the basis to answer our research questions.

Chapter 9: Simulation Test Cases

As already explained we adapted the Hoffmann theory to represent the way we see the influence of strategy on the alliance portfolio configuration. Hoffmann does have propositions he tests based on some case study-based data. In our research using our agent-based simulation we take this subjectivity out of the equation. We do take the causal links and the corresponding propositions as the starting point for our test cases because the changes in the alliance portfolio configuration as described by Hoffmann will still serve as test to check the two strategies we have chosen to test.

9.1: Propositions based on Hoffmann's (2007) propositions

Propositions 2 and 5 of Hoffmann (2007) are disregarded because they talk about the shaping strategy that we disregarded, based on our interpretation of the strategies. We made the translation that the shaping strategy equals the exploration strategy and the stabilizing strategy equals the exploitation. Propositions 7, 8 and 10 of Hoffmann (2007) are referring to cases where the strategy will change or when there is a combination of strategies. As explained in our design phase we chose to endow the firm's with a strategy, and they are unable to choose and therefore change their strategy. Therefore we disregard these propositions.

The first two propositions talk about the performance of a business in high and low uncertainty. These propositions automatically validate our second research question because they test the influence of strategic uncertainty on the performance. These propositions are testable using our simulation so we will base our test cases on these two propositions. The second set of propositions is declaring what the influence of the strategy on the alliance portfolio configuration is. We do not need specific test cases to test this, as we use the strategy in the other test cases we can use the data gathered out of these test cases. Based on the changes we proposed we translated the propositions 1 and 3 to:

Proposition 1: High strategic uncertainty favors forging alliances to implement an exploration strategy to increase the strategic flexibility of the focal business unit and build up a broad set of new competencies and relationships.

Proposition 2: In the case of low strategic uncertainty, alliances are used to exploit existing resources and to stabilize the business environment.

This first proposition will be the basis for our first test case that states that in high strategic uncertainty firms prefer to have an exploration strategy; this preference should be represented that these firms will have a higher performance in comparison to an adapting strategy. The second proposition states that in a low strategic uncertainty an exploitation strategy will create the best performance.

Validation

Hoffmann's fourth and sixth proposition are the propositions that talk about the influence of the strategy on the alliance portfolio configuration and therefore also covering the first sub research question. As we based our theory around these propositions we do not test these propositions but make them rules to which the simulation is validated on working correctly and in line with our line of reasoning. So we created the following two rules our simulation has to adhere to:

Rule1: When companies pursue an exploration strategy in a specific business, then the business-related alliance portfolio is characterized by a large number of alliances with high dispersion and weak linkage intensity as well as low redundancy.

Rule2: When companies pursue an exploitation strategy in a specific business, then the business-related alliance portfolio is characterized by a small number of alliances with low dispersion and strong linkage intensity as well as high redundancy.

So in every test case, using fixed strategies, it should be clear that when the firm uses an exploration strategy we should see the following characteristics in the alliance portfolio configuration (1) a large size, (2) high dispersion, (3) low strength and (4) low redundancy. Where the exploitation strategy should be characterized by a mirrored alliance portfolio configuration, as in: (1) a small size, (2) low dispersion, (3) high strength and (4) high redundancy.

9.2: Final Test Cases

Based on our propositions we expect that firms with an exploitation strategy will have an overall better performance (compared to firms with an exploration strategy) in an uncertain environment, meaning that there are high constraints to the firm's actions, high constraints to alliances and many changes in the industry; changing product values, changing product requirements and having changing alliance contracts. While when there is less to no uncertainty this switches. To test this we should have 2 test cases, based on our propositions we should have one test case where there is a high uncertainty (proposition 1) and one test case with low uncertainty (proposition 2). As explained we use rule 1 and 2 in both test cases to test if the data we collect is accurate.

We will run each test case with the same beginning situation 10 times and let it run for 100 steps. There are a lot of steps in the process, under which, the setup that uses random selection methods therefore running the simulation 10 times does not create the same output.

Test Case 1 – "Uncertain"	
Run time	100
Number of agents	50
Exploitation vs Exploration %	50%
Uncertainty	
Product Lifespan	Change random 1 – 5 steps
Alliance Contract time	Change random 1 – 5 steps

Test Case 2 – "Certain"	
Run time	100
Number of agents	50
Exploitation vs Exploration %	50%
Uncertainty	
Product Lifespan	No Change
Alliance Contract time	No Change

9.3: Simulation Settings and Sensitivity

Before gathering the simulation data we need to set the variables into a certain setting. We played around with the settings, where each setting influences the simulation in a different way. In this chapter we will explain the settings and why we set it the way we did. We eventually found that the settings as represented in figure 12 gave the best representation of the data.

In the strategic uncertainty part of the variables we have 3 different settings we are able to set, during the test cases with a certain environment all the uncertainty is turned off. During the test cases with a high uncertainty the contract time and the lifespan get values with a random value of 1 to 5. During test runs we found out that the option of new entries could better be turned off, because it just corrupted the data by influencing all the simulation data because they are based on averages.

Then for the Static / Setup variables where we start with the Industry's product requirements; as the matrix options give the option to start with a random situation or with a static situation each time. We chose for the random situation so that the overall average of the simulation data will cover all the possible scenarios. We chose to go for 5 products, having more products will only complicate and slow down the simulation, while it does not influence the generated data significantly. The amount of resource types per category is based on the idea that Grant & Baden-Fuller (2005) uses 18 different knowledge types in their comparison, using the value of 3 we now have 15 different resources. Next to this we also state that in the product requirements at least one of the subtypes of each resource category is required to deliver the product. Then for the last part we have the option to set the value of the product. We created the option to have this static based on a random value for each product, the same static value for each product, or adapted each turn based on the delivery of a product to the industry.

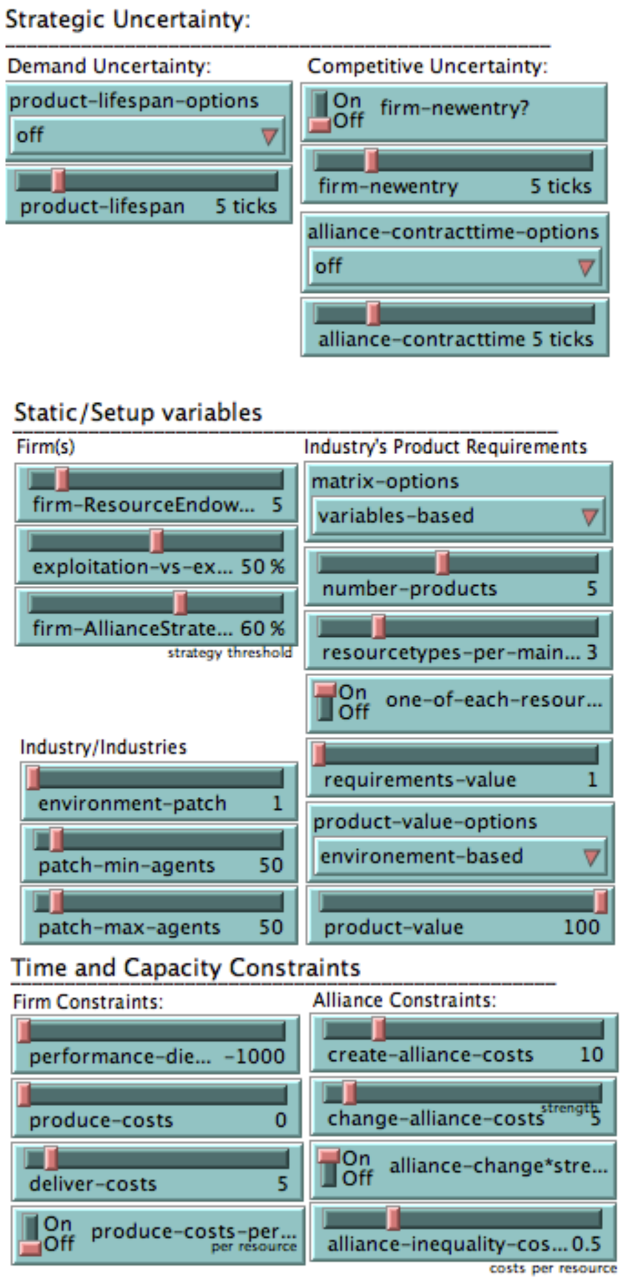

Figure 12 - Simulation settings

We chose this last option because this best represents market response if there are a lot of product X delivered to the market the value of this product will be less than a scarce product. We chose for a value of 100 to make sure that firms are able to at least cover the expenses they make each turn. Making this value lower will cause firms to die sooner, because their expenses are higher than the income. Changing this value will actually only influence the angle of the performance graph. A higher value means that firms will perform with higher numbers.

Continuing with the setup variables with the firm setup, we endowed the firms with a random of 5 for each resource, this way each firm is able to deliver a product to the industry and has enough resources to participate on the alliance market. The choose to endow 50% of the firms with the exploitation strategy and the other 50% with the exploration strategy is part of the decision we took in the test case situation. The last one is the alliance strategy threshold the influence of this slider is discussed in the design part. We chose to set this to 60% because we found out during testing that this way the firms are able to find partners, increasing the threshold will decrease the changes on creating alliances, decreasing it will decrease the strategy the firms follow and with that the validity of the simulation data.

The last setup settings are about the number of industries and agents in an industry. As we discussed this in the design phase we played with the idea of having multiple industries where firms were also able to create alliances outside their industry. To not complicate the simulation we decided to focus on one industry. The choice to use 50 firms in the simulation is based on constraints of the simulation; where 50 firms have the possibility to create 1225 links, based on an arithmetic series. Enlarging the number of firms will also enlarge the number of links and exponentially slowing down the simulation, while the simulation data isn't influenced significantly.

And for the last section of settings we continue to constraints. As discussed in the design section the division of the constraints from low to high should be: (1) deliver, (2) change alliance, (3) create alliance, (4) produce. We enforce each firm to produce at the beginning of each turn, therefore it does not influence the performance compared to each other and therefore we put this value to 0. The others comply to the order we discussed. Changing the values of these sliders will influence the performance, so when the constraints would have a higher value the performance will be less per step. Then the performance die point is set to -1000. During testing we realized that we saw that in the beginning firms had a negative performance, so they should have the possibility to startup and whenever a certain firm was performing bad, most of the times the firm was not able to save itself. So we set the die point in a way that firms are able to startup but when they would go bad they would be taken out of the equation. For the last setting there is the inequality costs that is set to 0.5, this way it does cost firms to startup unequal alliances, but as we do take this into account while searching for the best partner as well the costs shouldn't be too large. With that we did not see large changes when changing this value.

Chapter 10: Analyzing Simulation Data

After performing the two test cases, as proposed in Chapter 9, we collected the following data per step per strategy: the performance, the agent count and the alliance portfolio configuration. We combined the data and created graphs, presented in Appendix D, of the averages over 10 runs of each of the data elements. The graphs of the performance and agent is used to base our conclusions on, the alliance portfolio configuration data is used to validate the simulation by testing every test case on the rules 1 and 2, as presented in chapter 9.

10.1: Test Case 1 "Uncertain"

The first step in our analysis is cropping the data so that significant data remains. In the test case 1 data the agent count remained at a steady 25 exploitation firms to 25 exploration firms the same for the complete run, therefore we chose to dismiss this diagram. The data in test case 1 shows an obvious startup up to step 15 and after that it stays steady. So for the analysis of the data we will look at the data from 15 to 100.

After this we need to test if the data valid by checking rules 1 and 2, meaning that in the diagram Size and Dispersion the exploration should be above the exploitation line, and for the Redundancy and Intensity graphs this should be the opposite. Looking at the data it is clear that the data follows the two rules, and therefore the data correctly represents alliance portfolio configurations connected to these strategies. To prove this scientifically we also performed a Student T test, testing the set of data from the exploration strategy with the set of the exploration strategy for each graph. If the Student T test shows a high number this could mean that the data are similar and therefore could come from a glitch in the simulation. As you can see at the values, the values are nowhere near each other at any spot. The highest value of the Student T test is on the performance where we could say that the performances of the firms are very close to each other.

Finishing up we take a first look if the performance graph represents the proposition that it is testing. Proposition 1 tells that the performance of the exploration strategy should be better than the exploitation strategy in the uncertain environment simulated in test case 1. According to the data of test case 1 per se Proposition 1 is not true. We will discuss these findings in detail in the discussion section (10.3).

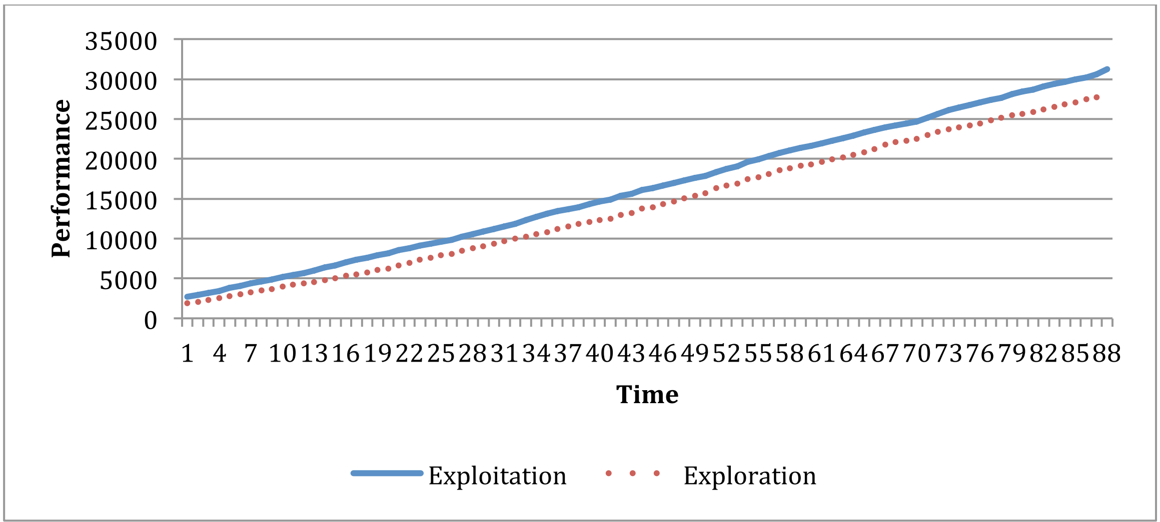

Figure 13 - Performance Test Case 1 "Uncertain"

10.2: Test Case 2 “Certain”

For test case 2 we performed the same steps, so we started off with extracting the significant data. We were unable to clearly declare a startup situation, so we decided to start the relevant data at step 0. For the other end of the data we took position 36 because at that point the firm count of the exploration strategy falls below 5 firms and the average values found after are not significant any more. So for our further analysis we look at the data from 0 to 36.

Looking at these diagrams and checking rules 1 and 2, we see that for the size, dispersion and redundancy where the exploration should be above the exploitation the rules are true. For the intensity this is a little bit more complicated. Because the settings allow the alliances to exist indefinitely, intensity will stay the same as firms are constantly searching for ways to add to their alliance portfolio without losing any alliances. In the long run the exploitation gets a larger intensity than the exploration as shown in the end of the graph. Concluding we state that the data represents the strategies correctly. The Student T tests show that all the data is far enough apart to stay below the 5%. For the small set of only 36 steps this proofs that the data is significantly different. The only value that is high is the 30% of the Intensity but we already discussed the reasons why this value is so high.

Finishing with the comparison of the data per se with the Proposition 2 that is tested, we see that the performance of the exploitation strategy exponentially outperforms the exploration strategy. So Proposition 2 holds true based on this data per se, we further discuss the test cases in the following discussion section.

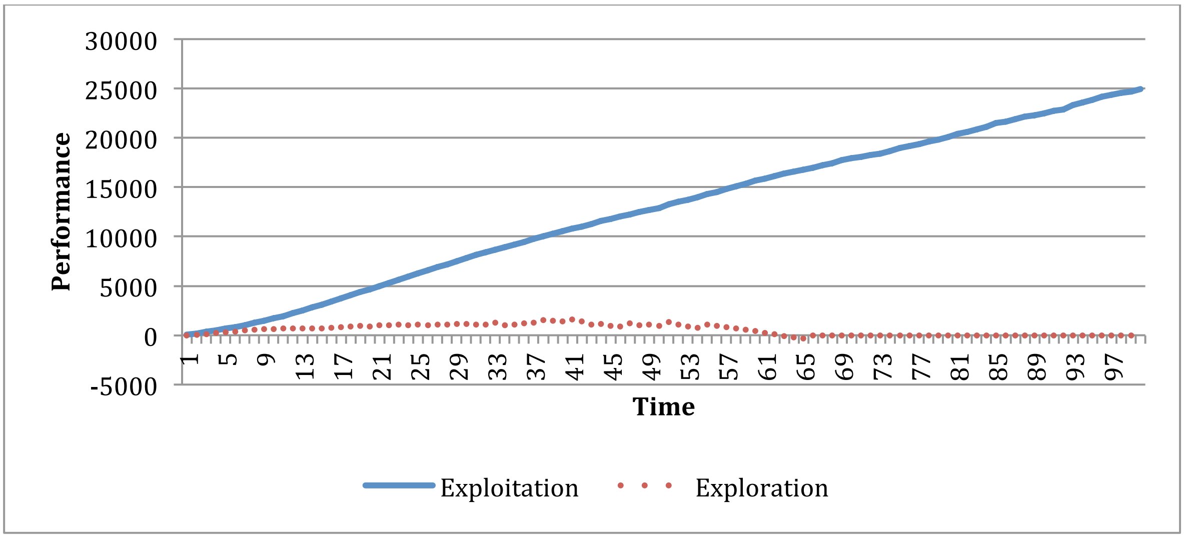

Figure 14 - Performance Test Case 2 "Certain"

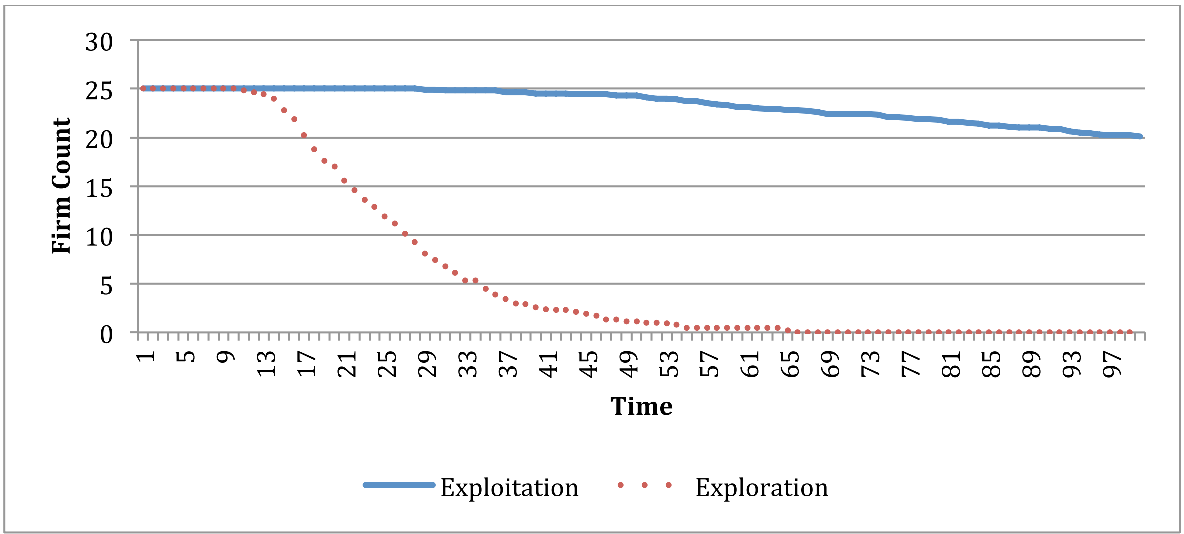

Figure 15 - Firm count Test Case 2 "Certain"

10.3: Conclusion and Discussion

Figures 13 to 15 illustrate how the two strategies perform under uncertain and certain strategic conditions. Looking at the data per se we already stated that Proposition 1 is not true and Proposition 2 is. This direct translation of data to proposition might not be the best way to test the propositions. If we compare the performance of the exploration strategies in both test cases we see a huge improvement in the first test case compared to the second test case. From this we can say that the exploration strategy does perform better under an uncertain environment compared to a certain environment. If we combine that with the comparable performance of both strategies we cannot indefinitely state that Proposition 1 is false.

There are some reasons we can think of why the simulation is unable to tip the performance in test case 1 in favor of the exploration strategy. One of the reasons is that the simulation is unable to generate enough uncertainty to tip the performance. We tested this by decreasing the uncertainty sliders, but in any simulation run we took we were unable to tip the scale. So to test this proposition we need to adapt or create a new simulation. Another possibility is that the adaptions we made to the theory of Hoffmann created a situation where the proposition is not true anymore. The final reason we can think of is that the theory of Hoffmann is not true in such a generalized case. Hoffmann does recognize that his proposed theory is based on the two case studies he performed and questions the general applicability of the theory.

What we can say next to the positive validation of Proposition 2 is that according to the acquired data the exploitation strategy is hardly influenced by the strategic uncertainty. We validated this by checking the alliance portfolio configuration characteristics to ensure that the strategies are doing that what Hoffmann proposed in their research.

CONCLUSION

Finalizing the research about the performance aspect of the exploration and exploitation strategies on Alliance Portfolio Configuration under strategic uncertainty we cover each of the three phases, as we declared in the research framework, and answer the sub and main research questions. After our conclusion we discuss the limitations of our research and how this research opens the way to future research.

Literature review

In our literature review we were able to explain different terms of the research question. We covered alliances and in detail the alliance portfolio configuration. In our research of the alliance portfolio literature we found that the research in this area is moving towards a firm-level perspective. Because of a lack of case studies in the field of alliance portfolio research, agent-based simulations are becoming a wider used method for generating data.

In our literature research we came across a paper of Hoffmann (2007) that proposes a framework in which strategies for alliance portfolio configuration are proposed. Furthermore this research proposes a cause-effect diagram in which the relation between alliance portfolio configuration, strategic uncertainty and performance is described. Although this research might cover most of our sub questions we had some remarks about the interpretation of the theories about: (1) resource based view, (2) contingency theory and (3) strategy. Eventually we changed the theories back to more general accepted theories.

We concluded by proposing an improved version of the cause-effect diagram of Hoffmann, as shown in Chapter 3 figure 7. With this proposed diagram we answered the first sub-question: “What is the influence of strategic uncertainty on the alliance portfolio configuration performance?”. According to our proposed framework when the strategic uncertainty grows the redundancy and linkage intensity is influenced in a negative way and the size and dispersion is influenced in a positive way. The performance is influenced by a growing resource endowment that improves the delivery opportunities of the firm. Performance in this case is generated by the sales of products to the industry.

Together with the proposed model we proposed to change the strategies back to just two strategies: exploration and exploitation. With this answering the second sub questions:

"What is the influence of strategy on the alliance portfolio configuration?" According to our proposed framework the exploitation strategy influences the alliance portfolio configuration by having a focus on redundancy and intensity, and the exploration strategy has a focus on size and dispersion.

Simulation

To test and validate our adapted cause-effect diagram we chose to use an agent based simulation approach. The main advantage of this is that no actual data is necessary to test and validate a theory. A downside on using agent based simulation for generating data is that this research area is still under heavy development, we eventually were able to find a tool, NetLogo, to help us translate our model to an agent based simulation. By firstly designing the simulation without the constraints of the NetLogo tool and after that adapting the design to the constraints of NetLogo, we created an agent-based simulation of our proposed cause-effect model.

Execution and interpretation

Based on the Hoffmann (2007) propositions and our sub-questions we found two propositions (covering the second sub research question) to test and two rules (covering the first sub research question) that validate the data generated by the test cases. The simulation supports the proposition that under little uncertainty the exploitation strategy will outperform the exploration strategy. The proposition stating that under high uncertainty the exploration strategy will prevail over the exploitation strategy does not hold true, but cannot be dismissed indefinitely. Because the exploration strategy does perform better than in the certain environment. Another conclusion we were able to subtract from the simulated data is that the exploitation strategy is hardly influenced by the strategic uncertainty.

Conclusion

Looking at our main research question:

How is the performance of alliance portfolio configuration strategies influenced by strategic uncertainty?

As explained in Chapter 3.3, we distinguish between two strategies: exploration and exploitation. Using simulation, we have compared the performance of these two strategies in an agent-based simulation. We can state that the exploration strategy performs badly under low uncertainty conditions; while under high uncertainty conditions the performance of the strategy is equal to the exploitation strategy. To the contrary, the exploitation strategy is not heavily influenced by the uncertainty or certainty of the environment.

Managerial Implications

As described in chapter 1.3 managers influence the configuration of the alliance portfolio greatly. In line with the conclusion of our research managers should use an exploitation strategy as long as possible. An exploration strategy will harm the firm when used under conditions where there is low strategic uncertainty. Under high uncertainty conditions the use of an exploration strategy alone on itself will not harm the firm nor create a higher profit.

Limitations

The limitations of our research can be largely found in two stages; (1) the adaptation of the Hoffmann model and (2) in the translation of the model to an agent-based simulation. The first limitation is that Hoffmann already questions the general usability of the model. One of the objectives we wanted to reach was to generalize the model. We believe that the adaptions we made did improve the model, but that the second set of limitations diminished the change on validating the model completely.

Because there is no real modeling guideline for agent-based simulations we were forced to lean on our knowledge of UML modeling and translating this into an agent-based simulation using NetLogo. One of the things we encountered during the translation of the model to simulation is that we were unable to perform actions on the alliance portfolio strategy if we did not let the strategy influence the delivery of products next to the strategy influencing the alliance portfolio configuration. Another thing we found running the simulation is that we created a lot of different variables that we can change. It took a while to find out the influence of each setting on the outcomes of the simulation. We do believe that the simulation generated the best data possible given the constraints set by this research project. Having more time and expertise in agent-based modeling can possibly create a better validation of the proposed model.

Future Research

Based on the limitation of our research, future research should focus on further developing and validating the proposed framework. As there are not a lot of use cases available we still believe in the power of agent-based simulations. One of the possible additions to the simulation could be the option of starting with a settled situation and compare the influence of strategic uncertainty from there. Another addition we thought of is the inclusion of more than two strategies, in example a hybrid strategy. The last addition that could be made is a function that let a firm balance the actions it is making to the profit it will make performing a certain action.

Furthermore there are opportunities created by all the extra data available in the simulation we did not use in our research. There is a lot of data available on how the alliance portfolio configuration influences the resource endowment of the firms. Another thing that we did not cover in our research is a more social network based approach, the simulations ability to show the changes in the network composition creates a lot of possibilities to research alliance network theories. Next to that someone could research the reasons why to get into an alliance with certain partners, using the reasons and separated resource attributes in the alliances.

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APPENDICES

APPENDIX A: CRITERIA EXPLANATION

Copied from: (Tobias & Hofmann, 2004).

General criteria

License:

1. Source code not available
2. Source code partly available, and only to selected institutions
3. Source code partly available
4. Source code only available to selected institutions
5. Source code freely available under GPL (GNU General Public License)
6. Source code freely available under LGPL (GNU Lesser General Public License), BSD License (Berkeley Software Distribution), or similar licenses

Documentation:

1. Incomplete or no technical documentation; documentation not being developed
2. Incomplete technical documentation, because still under development
3. Complete technical documentation of basic functions provided
4. Complete technical documentation of basic functions with additional functionality (such as online support, etc.) provided
5. Complete technical documentation of all libraries provided, also without feature 4
6. Complete technical documentation with additional functionality provided

Support:

1. No support
2. Poor general support (mailing lists, etc.) and no contact to developers and users
3. Good general support (mailing lists, etc.), but no contact to developers and users
4. Loose personal contact to developers and users, but poor general support
5. Loose personal contact to developers and users, but good general support
6. Intensive personal contact to developers and users also without good general support

User base

1. Used only by the developer or never
2. Used by at least two research groups, any scientific field
3. Use by many research groups, any scientific field
4. Used by many social scientific research groups
5. Established and recognized in at least one scientific community (AI / simulation, social sciences, or practice)
6. Established and recognized in the social scientific community

<u>Future viability:</u>

1. The product is already outdated and is no longer being maintained
2. Support and maintenance have been assured to date, but are planned to terminate
3. Support and maintenance not assured due to developer's lack of resources
4. Support and maintenance assured, but it is not clear for how long (for example, in the case of professional "one-man operations")
5. Support and maintenance of the product assured for the next five years
6. Support and maintenance of the product assured for the next ten years

Modeling and Experimentation Criteria

<u>Support for modeling:</u>

1. Only Java functionality supported
2. Functionality for simple GUI (graphical user interface; visualization) and data analysis functions
3. Advanced GUI und data analysis functions supported
4. Functionality for frequently used procedures in content-theoretical modeling
5. Ready-to-use functionality that eliminate most of the programming work
6. Content-theoretical modeling possible without programming knowledge

<u>Support for simulation control:</u>

1. Only Java functionality supported
2. Simple simulation control (user can run the simulation, and no more)
3. Advanced simulation control (such as formal logic-based solution of the stepping problem)
4. Flexible simulation control (such as changing parameters at a certain step)
5. Dynamic simulation control (such as changing parameters in dependency on other parameters)
6. Extended functionality (such as integration of differential equations, etc.)

<u>Support for experimentation:</u>

1. Only Java functionality is supported
2. Simple functions for control and recording of simulation series
3. Advanced functions for control and recording of simulation series
4. Ready-to-use Monte Carlo simulations
5. Simple parameter optimization algorithms
6. Advanced parameter optimization algorithms

<u>Support for project organization:</u>

1. Only Java functionality is supported
2. Simple management of models and model parts
3. Simple management of simulation runs and experimental series
4. Advanced management of models and model elements
5. Advanced management of simulation runs and experimental series
6. Advanced management and versioning

Ease of use:

1. Difficult to use even with strong programming skills
2. Requires strong programming skills, but then easy to use
3. Easy to use if modeler has knowledge of Java
4. Easy to use if modeler has elementary programming skills
5. Text-based user interface usable by lay people
6. Graphical user interface usable by lay people

Support for communication:

1. Communicated only in normal Java code
2. Model and documentation can be linked (such as sensitive online support).
3. Model can be executed remotely on the Web
4. Documentation aids (such as automatic visualization) available, but not features 2 and 3 above
5. Features 2 and 4 above
6. Both features 3 and 4 above

Ease of installation (as indicator of reliability and efficiency):

1. Could not be installed by evaluation team
2. Difficult to install even with support
3. Easy to install with support
4. Error-free, fast installation, but runs unstably
5. Error-free, fast installation, runs stably
6. Installation easy for lay people

Modeling Options Criteria

Large number of complex agents:

1. Only a few, simple agents are supported
2. Only simple agents are supported, but large populations are possible
3. Only a few agents are supported, but they can be very complex
4. Relatively many, complex agents are supported, but there are limitations
5. No limitations on number and complexity of agents, but requires a lot of memory storage and computing time.
6. As in 5 above; in addition, memory management and computing organization is very efficient.

Inter-agent communication:

1. No inter-agent exchange supported, must be programmed using Java.
2. Inter-agent exchange as such is not supported, but structures and methods are provided that simplify and accelerate data searching
3. Data exchange between agents is supported, but only rudimentary patterns can be implemented (such as calls for variable values), and computing time is slow
4. Data exchange between agents is supported, but only rudimentary patterns can be implemented, which, however, are computed rapidly
5. Complex data exchange processes can be programmed easily, but computing time of the processes is slow
6. Complex data exchange processes can be programmed easily and computed rapidly

Nesting of agents:

1. No nesting possible.
2. Only a limited number of levels possible; limited agent types (for example, super-ordinate agent is passive)
3. Only a limited number of levels possible, but any number of agents can be built from other agents. Sub-agents lose their "autonomy" (for example, an agent can be built from various modules, but not a group from members)
4. As in 3 above, but no limit to the number of levels
5. Any number of agents can be built from other agents, whereby sub-agents can still be managed as autonomous agents. However, limited number of levels possible.
6. As in 5 above, but no limit to number of levels.

Generating agent populations:

1. No procedure for automatically generating populations supported
2. Data import supported: agents can be generated from data
3. Agents can be generated based on simple statistical values (such as means and standard deviation)
4. As in 3 above, but more complex generators supported (for example, varying distributions, etc.)
5. Simple projection algorithms for generating a population based on imported data of a sample (for example, copy based on weighting)
6. As in 5 above, but more complex algorithms (such as probabilistic methods).

Generating networks:

1. No procedure for automatically networking agents implemented
2. Elementary networks supported (such as all agents networked with all other agents, random networks)
3. Automatic generation of networks based on non-social scientific control information (such as networking of all agents within a certain distance, in the sense of spatial interaction)
4. Automatic generation of networks of agents based on social scientific control information (such as network density, centralization, etc.)
5. Automatic generation of networks based on characteristics (such as networking agents having similar attitudes) and control information
6. Automatic generation of networks based on combinations of characteristics and control information

Management of spatial arrangements:

1. No procedures for managing spatial arrangements implemented
2. Simple spatial functionality (agents possess a spatial position, simple movements supported)
3. Simple positioning algorithms (such as decreasing density with increasing distance from a certain point)
4. Simple areas of influence (for example, all agents at a particular distance from active agents can be determined)
5. Complex areas of influence (such as possibility for visual obstacles)
6. Complex positioning algorithms (such as optimization of position based on various bits of inexact position information)

Dynamically changing the model structure:

1. No changing of structure during model execution possible
2. Changing of network during model execution possible
3. New agents can be generated and existing agents can be eliminated during model execution
4. The structure of agents and networks can be changed during model execution
5. As in 4 above, in addition automatic control of structural change processes (such as "aging").
6. As in 5 above, in addition these processes can be changed through simulation and experimental control

APPENDIX B: TECHNICAL SIMULATION DESIGN

We used the class diagram as presented in Chapter 7 by figure 10 to specify the required variables; these are represented on the interface or at the beginning of the code. The procedures are based on the adapted cause-effect diagram, Chapter 3 in figure 7. We start with the explanation of the interface, so that it becomes clear what all the variables and buttons are representing. Next we will explain the procedures by using an adaption of state chart diagram techniques to visualize the steps the simulation takes. We will shortly explain each of the steps and in some cases will include the responding piece of code.

Interface

A complete caption of the interface is shown in Appendix C. There are a lot of things happening on the interface. We have cut the interface in four parts; (1) on the left hand side are all the variables that can be changed to setup and run the simulation in different settings, (2) in the center at the top are all the buttons that set the simulation in motion, (3) in the middle is the visual representation of the world and (4) on the right are all the graphs and monitors of different dependable variables. We will discuss each part individually.

Variables

As you can see in the interface there are a lot of sliders in the interface so it means we have a lot of variables we can change. We will give a short explanation per variable.

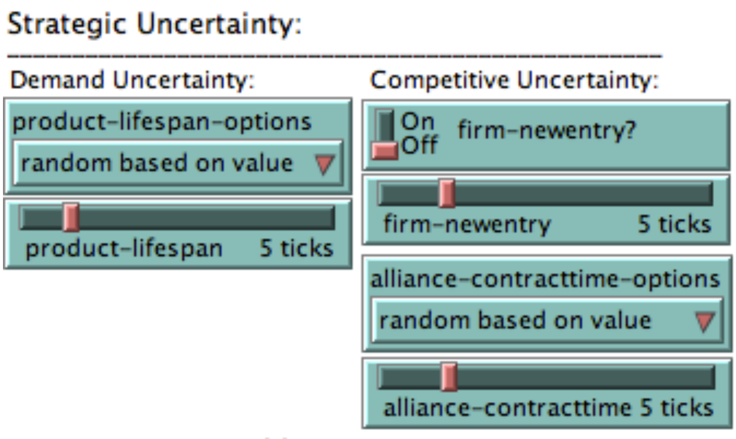


Figure 16 - Interface - Variables: Strategic Uncertainty

In the first section (figure 17) the variables control the uncertainty. As discussed in Chapter 7.1 we have three elements to control the uncertainty. The first is the lifespan, there are three options: (1) off, (2) all products the same lifespan based on the slider's value below and (3) a random lifespan for each product based on the slider's value. Secondly we have the entry of new firms into the industry, there are two options: (1) on or (2) off, if the option is set to on: the slider controls when a new firm is added to the industry. The last option for uncertainty is created by the contract time of the alliances created. This also contains three options: (1) off, (2) all the same contract time based on the slider's value below or (3) random for each alliance based on the slider's value.

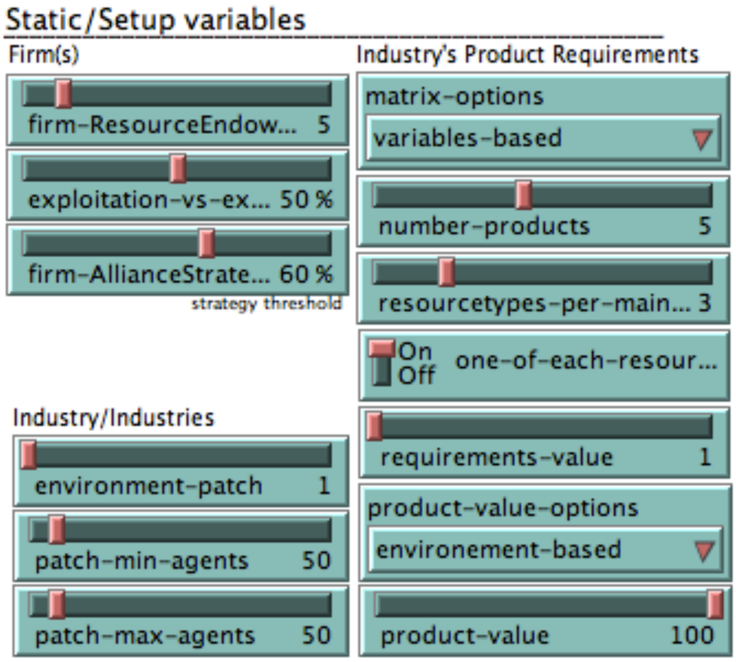


Figure 17 - Interface - Variables: Static/Setup variables

The second section of variables, see figure 18, are concerned with the setup of the simulation. The first subsection controls the variables for the firm. First there is the endowment variable, this variable is used to create a set with random values based on this variable for each available resource for each firm individually. This set of resources is the set that is used in the produce procedure. Second variable is the value that controls the amount of firms having an exploration strategy or an exploitation strategy, where the strategies are divided among the firms based on the percentage. The percentage actually represents the percentage of exploration strategy endowed firms. The rest of the firms is endowed with the exploitation strategy. The last variable in this subsection is the threshold, which is used in the "FindPartner" procedure. The threshold controls when a firm pursues a certain alliance or when it doesn't. The second subset of variables controls the amount of industries and firms, the first variable is controlling the amount of industries. In the first versions of the simulation we thought of creating different industries, but faced with all the constraints that would bring we decided that the industries should just stay on one. The simulation however does support the option but does not differ from firms in one industry or the other. The second and third variable of this subsection control the amount of firms in the simulation. The first controls the minimum amount of agents in the industry and the second controls the maximum amount of firms in the industry. If the values are the same then the industry contains the exact amount of firms. If not, then there will be a random amount that lies between the two variables. The last subsection controls the products. First there are two options to base the requirements matrix on: (1) the variables (number-products, resource types and value) or (2) a matrix that is specified within the code in procedure: "patch-CreateProductRequirements". The product variables controls the amount of products the industry has. The resource types are the types per main resource, where the main resources are set in the "setup" procedure to: research & development (rd), manufacturing (mnf), marketing (mrk), management (mng) and finance (fin). So if the variable for resource type is 3 there are 15 different resources. After that there is the option that controls that in the requirements at least one of each main category resources is required. Next we have the variable controlling the value of each of the resources. So for each product, a set of resources is created where each resource has a random value based on the requirement-value variable. The last pair of variables of this section are connected with the value connected to each product; (1) each product has a random value based on the slider, (2) all the products have the same value based on the slider, (3) the products have a value based on a list hard coded into the "patch-CreateProductValue" procedure and (4) the products have a combined value of the number of products times the value of the slider and this amount is divided based on the percentage of the products sold where the lowest market share gets the highest value.

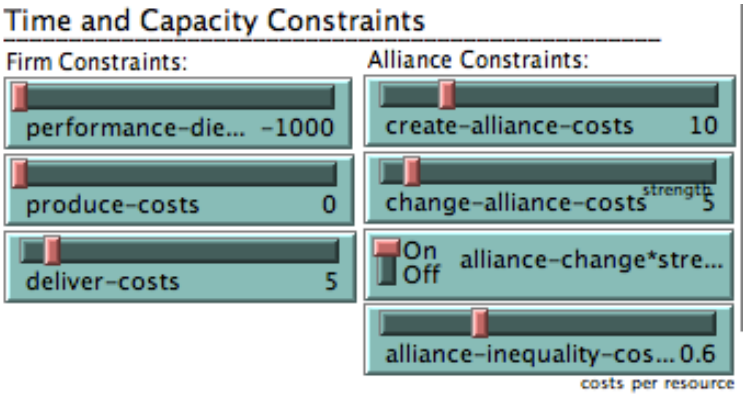


Figure 18 - Interface - Variables: Time and Capacity Constraints

The last section of variables, as shown in figure 19, controls the constraints of the simulation. The first variable is the "performance-die-point" specifying at what point the firm is not viable any more and should be excluded from the simulation. The next are costs to perform certain actions for a firm, such as produce, deliver, create and change alliances. The change-alliance-costs can also be influenced by the option to have the strength of an alliance influence the costs to change it. The longer an alliance holds true the cheaper it gets to make changes to that alliance. The last variable in the section is the alliance-inequality-costs, this is the variable that declares how expensive it is to have an unequal alliance, for each amount of resources that is different these costs are charged.

Buttons

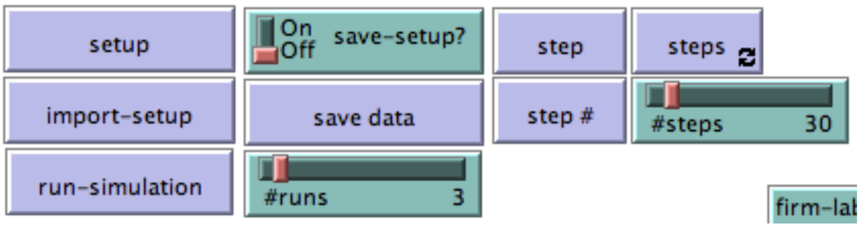


Figure 19 - Interface - Buttons

The buttons (figure 20) control the simulation and are fairly easy to explain: the button "setup", is connected to the procedure setup and will setup the environment with the variables declared in the "Static/Setup Variables" section. The " save-setup?" will open a directory selection screen at the end of the setup procedure asking where the setup should be saved. The button "import-setup" will open a file selection screen, where the user is able to select a file saved using the "save-setup?" option and then the simulation will import the setup based on this file. The button "save data" will export the plots as comma-separated files and the interface as a picture to the directory that is selected. Then there are three buttons on the right all referring to the step procedure, (1) the "step" executes the procedure ones, (2) the "steps" button lets the procedure run unlimited until the button is pressed again, (3) the "step #" button lets the procedure run the amount of steps based on the slider. Then there is the last button "run-simulation" this lets the simulation repeat the "setup", "step #" and "save data" for the amount specified by the slider, to support the save data a directory is chosen and in this directory all the data is saved with an addition indicating which run the data is from.

World

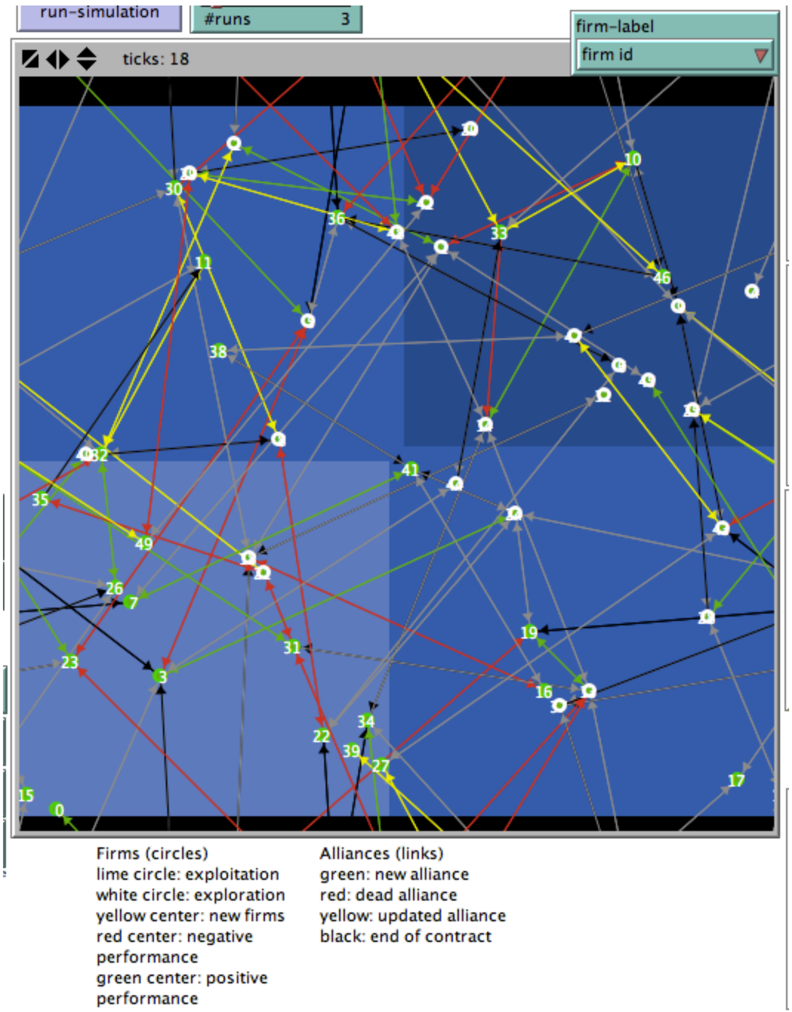


Figure 20 - Interface - World

The world is the visual representation of the current situation of the total simulation environment (figure 21), where circles are representing firms, lines are representing alliances and the (blue) colored area is the industry. In the bar above the world a count is shown, representing the steps (or ticks) the simulation currently has made. Then there is one option in the world area and that is the option what label the firms carry; (1) no label,

(2) the id of the firm and (3) the products and the amount delivered to the industry by the firm. Then there are the firms represented by circles, as explained below the world area, the lime circles are the firms with an exploitation strategy and the one with a white circle are the ones with an exploration strategy. The centers of the circles represent the status of the firms, yellow for new, red for a negative performance and green for a positive performance. For the alliances, represented by lines, there is a color representation as well, green for a new alliance, red for a dead alliance, yellow for a changed or updated alliance and black for an alliance that reached the end of its contract.

Graphs and Monitors

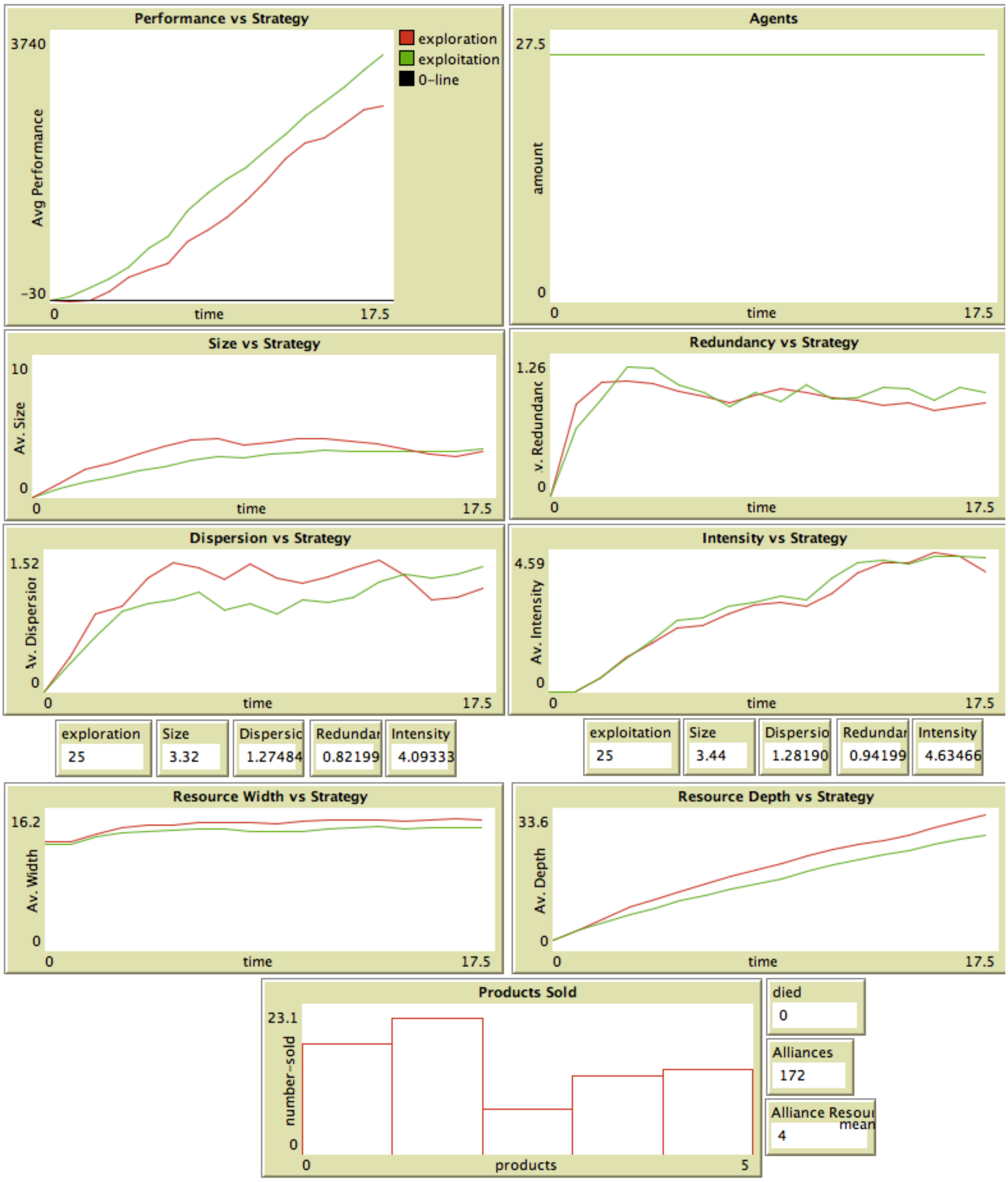


Figure 21 - Interface - Graphs and Monitors

All the graphs and monitors as shown in figure 22 are actually self-explanatory. The things you need to know is that in all the graphs except for the products sold there are two lines where the green line is always representing the firms with an exploration strategy and a red line representing the exploitation strategy endowed firms. The values of the monitors are linked to the strategy mentioned in the most left of that series of monitors. For the products sold graph and the monitors next to it holds that they are visualizations for the complete simulation.

Code

In this chapter we will shortly explain the procedures of the simulation and the order in which they take place. To visualize this we used the state chart diagram method but used it loosely and in an unofficial manner, so that it contains more textual explanations.

We will explain the two main procedures: (1) setup and (2) step. During the explanation we will go into procedures that are nested in the initial procedure. For the important procedures we included the code.

We will not explain the layout and help procedures as we then would explain things that are not directly linked to the outcome of the simulation, which would only complicate the design explanation.

Setup

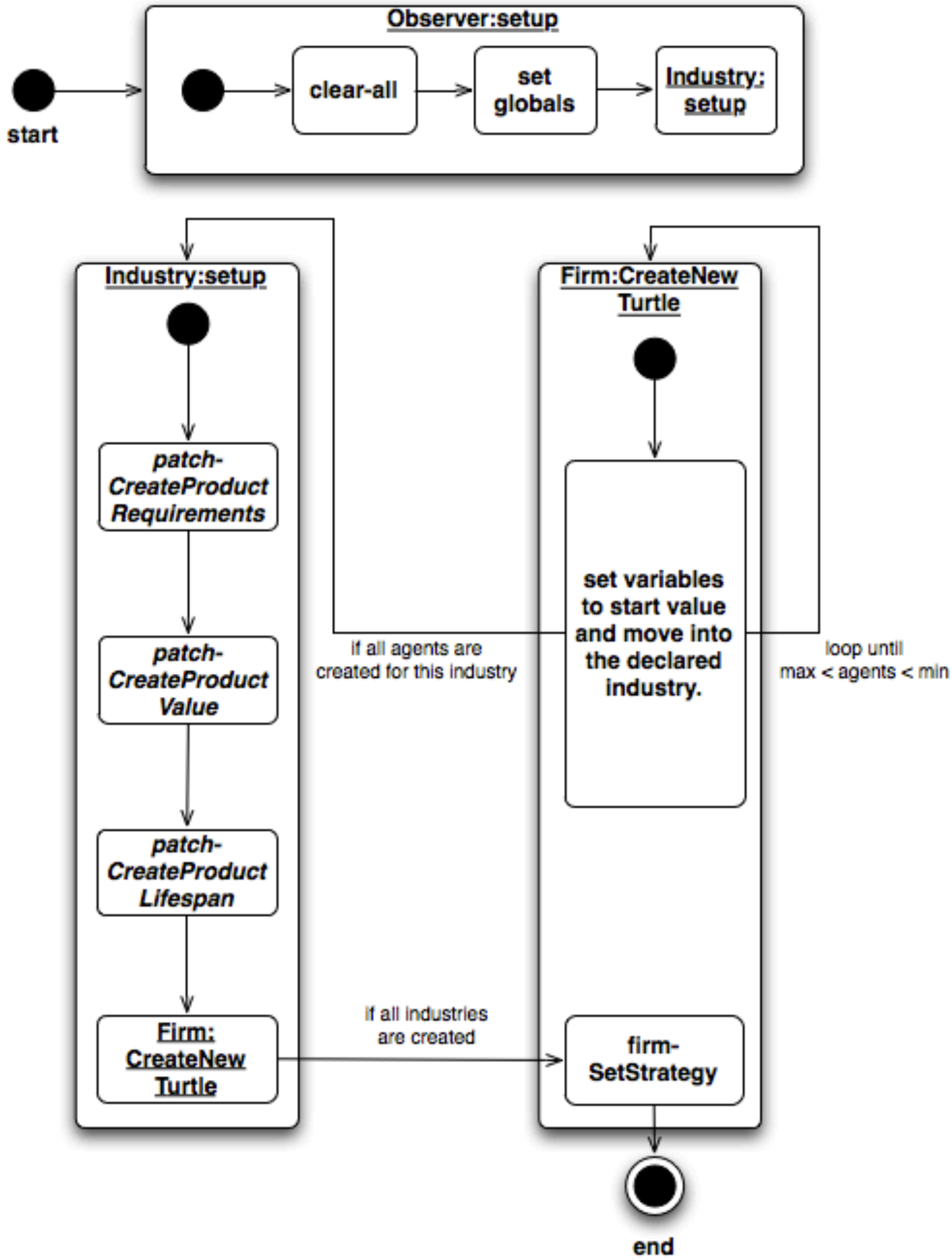


Figure 22 - Code - Setup

The setup, as shown in figure 23, starts by clearing the world and creating a new world based on the variables set in the interface. The simulation creates the industry, including the product requirement matrix, product values and its agents, and loops until all the industries are created. At the end of this process all the firms are endowed with their strategy. We placed this on the end, because otherwise we couldn't use the division of percentages.

Step

The step procedure is the actual procedure that makes the simulation run. So in this case we will see nested procedure. The visualization of this procedure is found in figure 24.

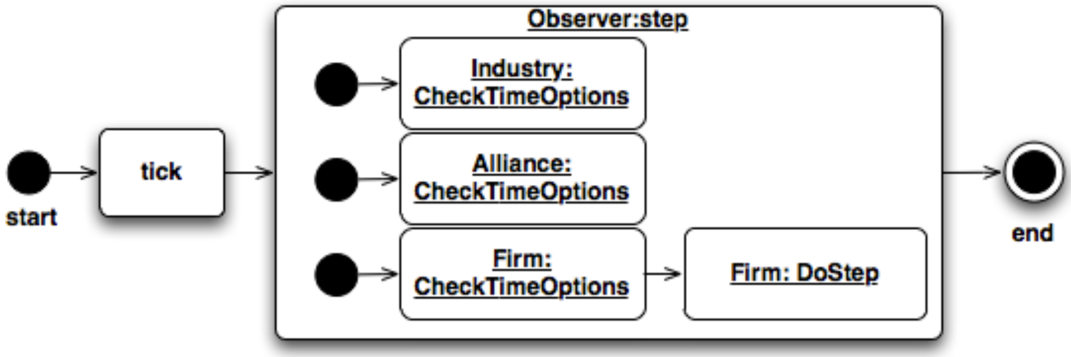


Figure 23 - Code - Step

In this first step we see that the step count is increased directly by tick action. Then after that all the elements will check for time constraint elements, see figure 25 to 27.

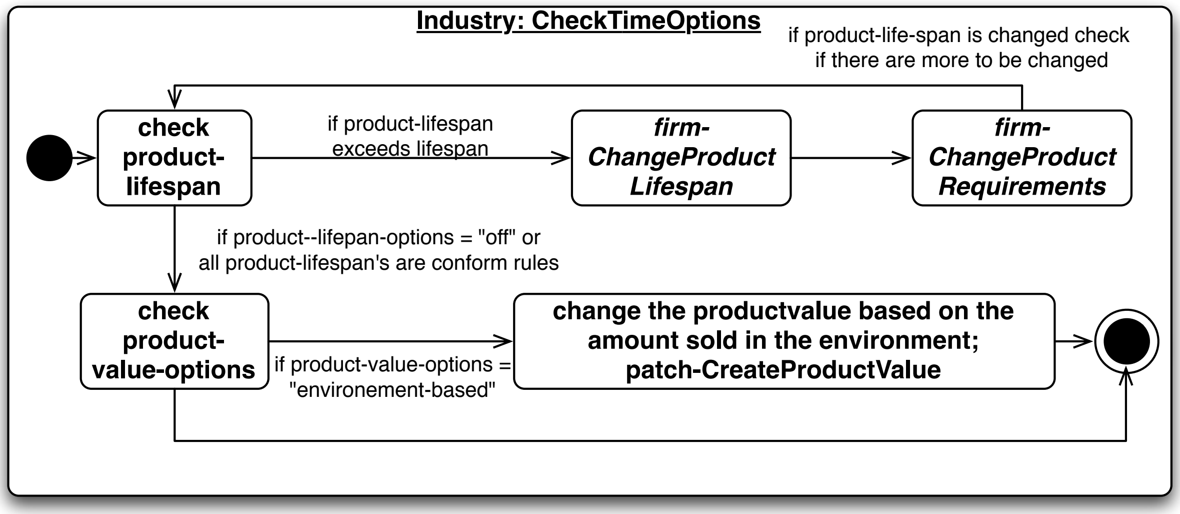


Figure 24 - Code - Industry:ChecktimeOptions

In the industry (figure 25) the lifespan should be checked, if the lifespan has been exceeded the industry will change the lifespan and the requirements of that product. If the product-value option is set to environment, the values of the products are redefined every step.

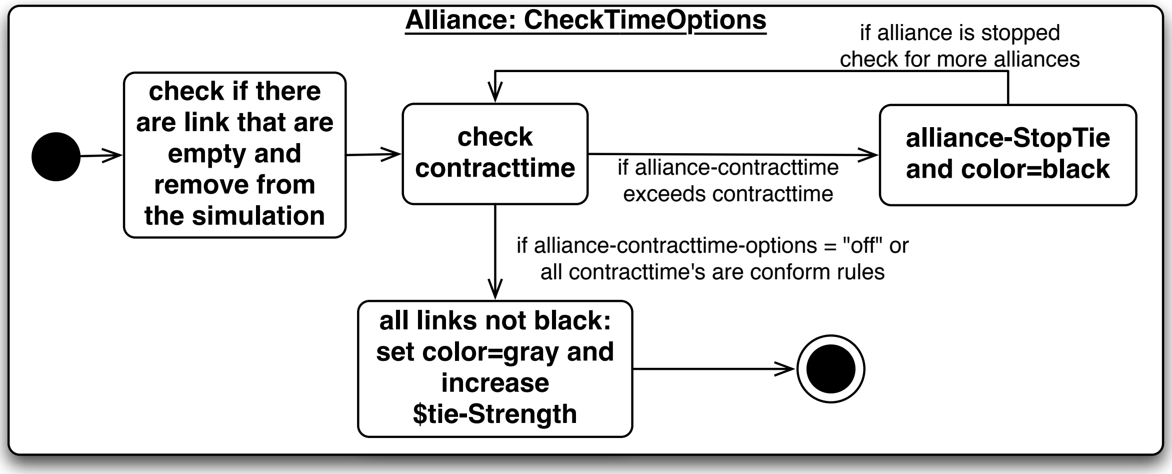


Figure 25 - Code - Alliance:CheckTimeOptions

For the alliances (figure 26) the contract time should be checked to see if the contracts have ended. If so the alliance should be stopped and will change color.

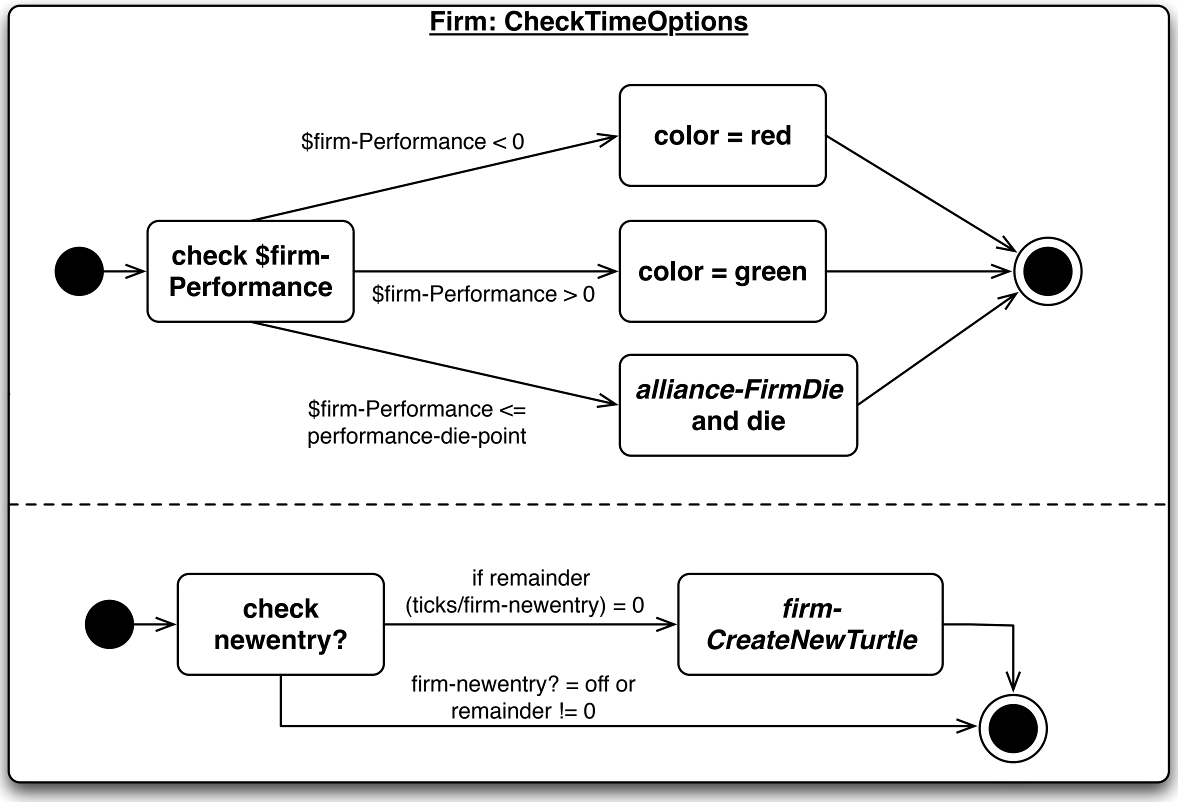


Figure 26 - Code - Firm:CheckTimeOptions

Within the firms there are two things that are checked (figure 27): (1) the performance and (2) if the industry allows new firms to enter the industry. In the case of the performance it is checked if the firm is “bankrupt” according to the “performance-die-point” set in the interface and if not what color it should have based on their performance. If new firms are allowed it will add firms when the time has passed.

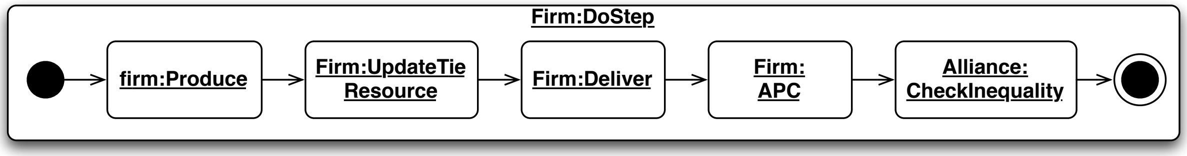


Figure 27 - Code - Firm:DoStep

The next procedure, shown in figure 28, actually lets the firms make their actions. These actions are derived from the adapted flow chart in Chapter 7.5 and are made into procedures. Each firm will perform the following actions: produce resources, exchange the resources over the alliances, deliver products to the industry, change the alliance portfolio (Firm:APC) and pay for any inequalities in the alliances.

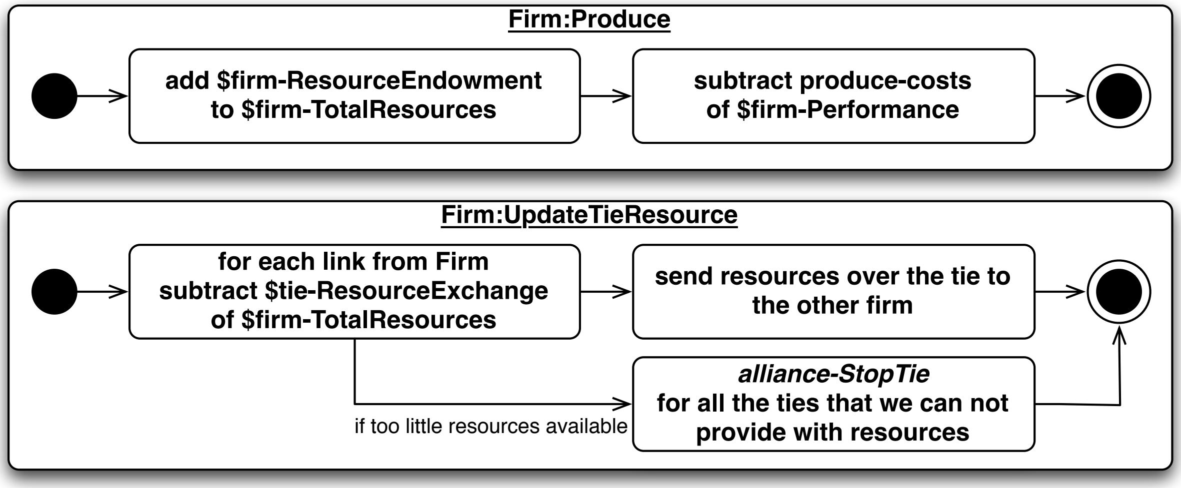


Figure 28 - Code - Firm:Produce and Firm:UpdateTieResource

The procedures "produce" and "gather resources from the alliances", combined in figure 29, are actually quite straightforward in the first procedure; the production list of resources that is endowed to the firm is added to the total resources of the firm. Then for all the alliances the resources are exchanged to the other party. If the firm is not able to exchange the resources specified in the alliance contract that alliance will be stopped.

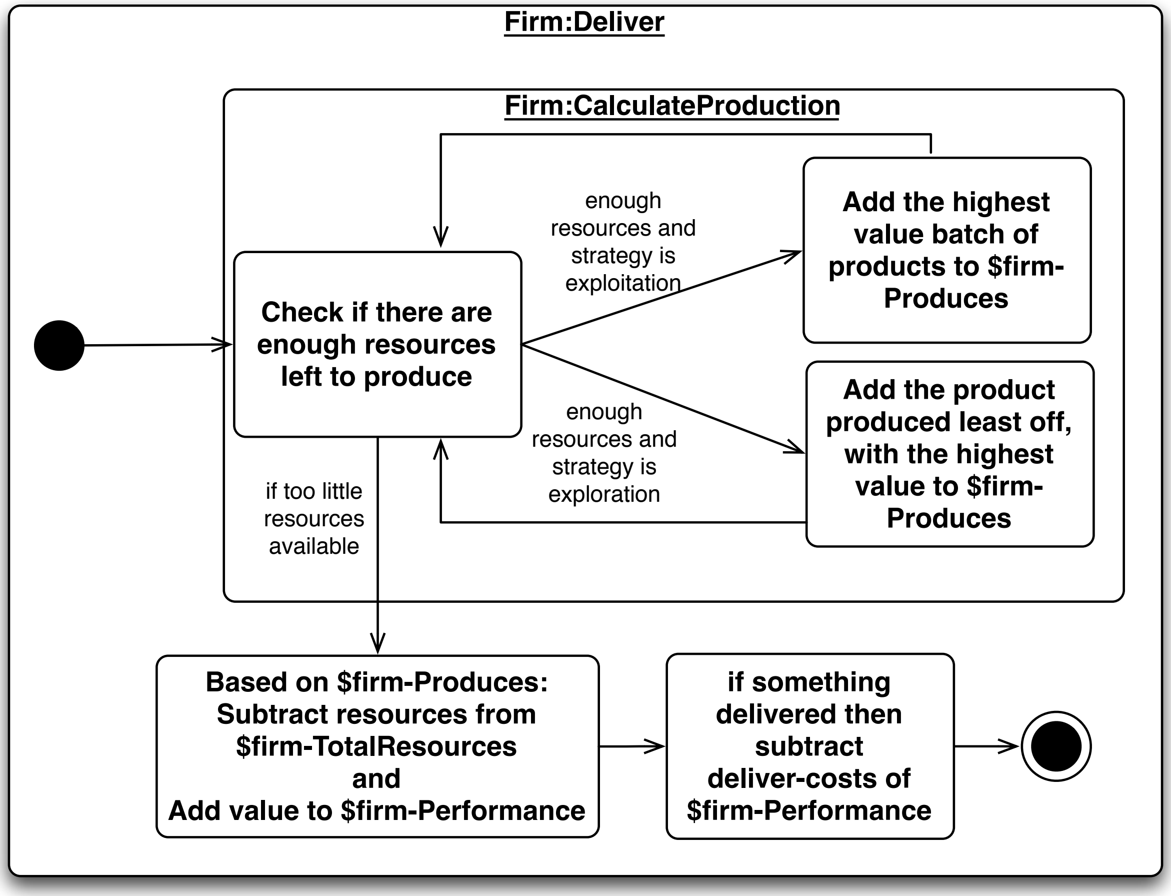


Figure 29 - Code - Firm:Deliver

In the deliver procedure (figure 30) the first use of the strategy is made clear, because within the delivery there is a function that calculates the best production scheme. This scheme is then executed and therefore subtracting the resources and adding the value to the performance.

In code 1 you see the code for the calculation process; it starts with an empty production scheme list and then splits up into the two strategies. The first one is the exploitation where first a table is created with how often a product can be made (multiplicity) with all the resources currently available. Then this table is multiplied with the corresponding values thus creating a list of value that can be gathered. It takes the one with the highest value and adds the multiplicity of the corresponding value to the production scheme. This process continues until all the resources are used or until no products can be produced any more. The second one is the exploration strategy where the product with the highest value is added to the production scheme if the product requirements are met. Than the product with the highest value after that is taken and tested for product requirements, etcetera.

Until all the products are covered and these steps are repeated until no products can be made any more.

```
to-report firm-CalculateProduction [resources]
  let production n-values number-products [0] ;; List with a sublist containing productnumber and multiplicity
  let empty false
  let productvalue [$patch-ProductValue] of patch-here
  ;; This is an "exploitation" function that finds the most products able to create, next checks the combination
  ;; that gathers the most value for the firm, produces that one first, next redo this search until all resources
  ;; have been used.
  ifelse ($firm-Strategy = "exploitation")[
    while [not empty][
      let run1 0
      let multiplicity [ ]
      while [run1 < length production] [
        let productreq matrix:get-row [$patch-ProductRequirements] of patch-here run1
        set multiplicity lput firm-DeliverMultiplicity productreq resources multiplicity
        set run1 run1 + 1
      ]
      ifelse (max multiplicity > 0)[
        let val-multiplicity global-ListsMultiply multiplicity productvalue
        let products global-SortedListsMaxMinPositions (sort-by [?1 > ?2] val-multiplicity) val-multiplicity
        let product item 0 (shuffle products)
        set resources global-ListsSubstract resources map [(item product multiplicity) * ?]
                                            (matrix:get-row [$patch-ProductRequirements] of patch-here product)
        set production replace-item product production (item product production + item product multiplicity)
      ][  set empty true ]
    ]
  ][
  ;; This is the "exploration" function where we try to produce the product with the highest value first,
  ;; then with the one with lesser value, etc until all resources have been used.
    while [not empty][
      let unable 0
      set productvalue [$patch-ProductValue] of patch-here
      while [sum productvalue > 0][
        let products global-SortedListsMaxMinPositions (sort-by [?1 > ?2] productvalue) productvalue
        set products shuffle products
        let run2 0
        while [run2 < length products][
          let product (item run2 products)
          let productreq (matrix:get-row [$patch-ProductRequirements] of patch-here product)
          ifelse (min (global-ListsSubstract resources productreq) > 0)[
            set resources global-ListsSubstract resources productreq
            set production replace-item product production ((item product production) + 1)
          ][
            set unable unable + 1
          ]
          set productvalue replace-item product productvalue 0
          set run2 run2 + 1
        ]
      ]
      if (unable = (length [$patch-ProductValue] of patch-here))[ set empty true ]
    ]
  ]
  report production
end
```

Code 1 - firm-CalculateProduction

We will first cover the inequality costs procedure, in figure 31, because the procedure for changing the firm's alliance portfolio configuration is extensive and has multiple nested procedures. The check for inequality is performed by the links themselves, each link checks if they both contribute to the alliance equally and if not the one firm pays the inequality costs to the other firm.

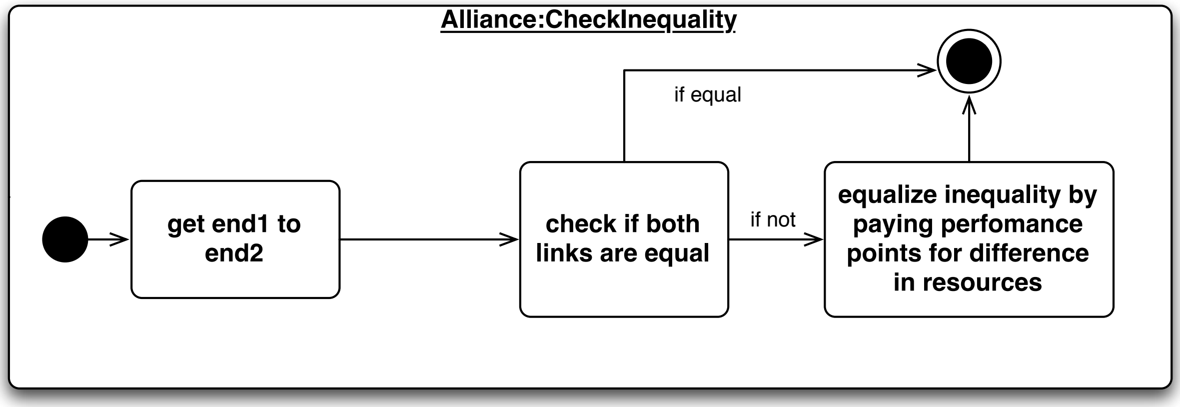


Figure 30 - Code - Alliance:CheckInequality

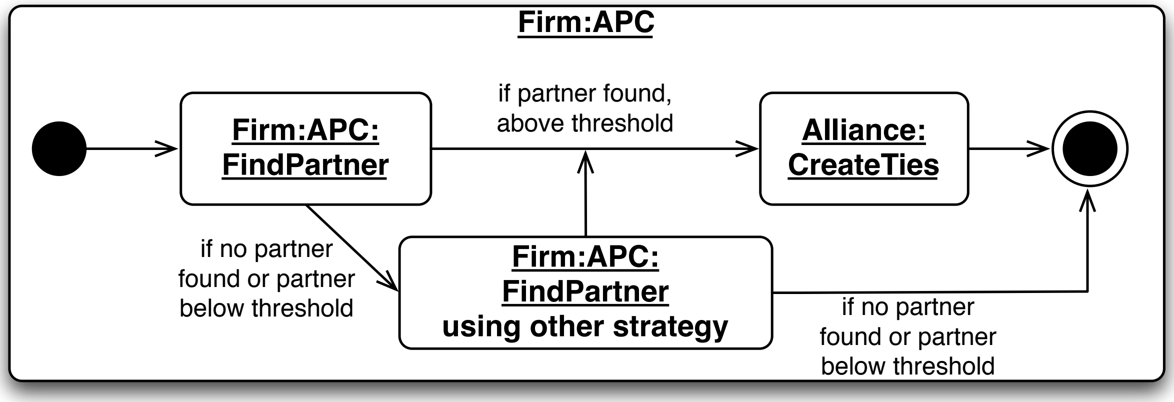


Figure 31 - Code - Firm:APC

The firm's procedure (see figure 32 and code 2) to change the alliance portfolio is actually one of the main procedures in the simulation because this actually creates and changes alliances. In the first step the firm tries to find a partner if they did not find any partner or the partner they found is not above the threshold the firm tries to use the other strategy to find a better partner. This is done because in the startup phase the exploitation strategy is not able to search within their current alliances because there are none. If an alliance partner is found that comes above the threshold the alliance is created, see code 3.

```
;; Do the alliance actions based on the strategy for the firm
;; Rewritten in v15: To add all the steps of finding a partner
;; and creating the alliance in one. This to incorporate the new
;; firm-DetermineAllianceDemands and AllianceOffer functions.
;; --------------------------
to firm-APC
  set $alliance-Shared $global-EmptyResourceList
  let partnercontract firm-APC-FindPartner $firm-Strategy 0

  ;; If the strategy is not able to find a partner that is larger than the treshold (firm-AllianceSuccesPerc)
  ;; then search the rest of the turtles.
  if (item 0 partnercontract = nobody or item 0 partnercontract = self or item 1 partnercontract < firm-AllianceStrategyThreshold)[
    let temppartnercontract [ ]
    ifelse ($firm-Strategy = "exploration")[
      set temppartnercontract firm-APC-FindPartner "exploitation" item 1 partnercontract
    ][
      set temppartnercontract firm-APC-FindPartner "exploration" item 1 partnercontract
    ]

    ifelse (item 1 partnercontract < item 1 temppartnercontract and item 1 temppartnercontract > firm-AllianceStrategyThreshold)[
      set partnercontract temppartnercontract
    ][
      set partnercontract replace-item 0 partnercontract nobody
    ]
  ]

  if (item 0 partnercontract != nobody and item 0 partnercontract != self)[
    alliance-CreateTies (item 0 partnercontract) (item 2 partnercontract)
    set $alliance-Shared global-ListsAdd global-ListsAdd $alliance-Shared (item 2 (item 2 partnercontract)) (item 2 (item 3 partnercontract))

    ask (item 0 partnercontract) [
      alliance-CreateTies myself (item 3 partnercontract)
      set $alliance-Shared global-ListsAdd global-ListsAdd $alliance-Shared (item 3 (item 2 partnercontract)) (item 3 (item 3 partnercontract))
    ]
  ]
end
```

Code 2 - firm-APC

```
to alliance-CreateTies [node contractside]

  let product item 1 contractside
  let resources item 2 contractside

  if (node != nobody and not empty? resources)[
    ifelse (in-link-neighbor? node)[
      ask in-link-from node [
        set color yellow
        set $tie-ProductResources alliance-ChangeResources resources product
      ]
      set $firm-Performance $firm-Performance - alliance-CalculateChangeAllianceCosts node
    ][
      create-link-from node [
        set color green
        set $tie-ProductResources $global-EmptyProductResources
        set $tie-Strength 0
        set $tie-ProductResources alliance-ChangeResources resources product
      ]
      set $firm-Performance $firm-Performance - create-alliance-costs
    ]
  ]
end
```

Code 3 - alliance-CreateTies

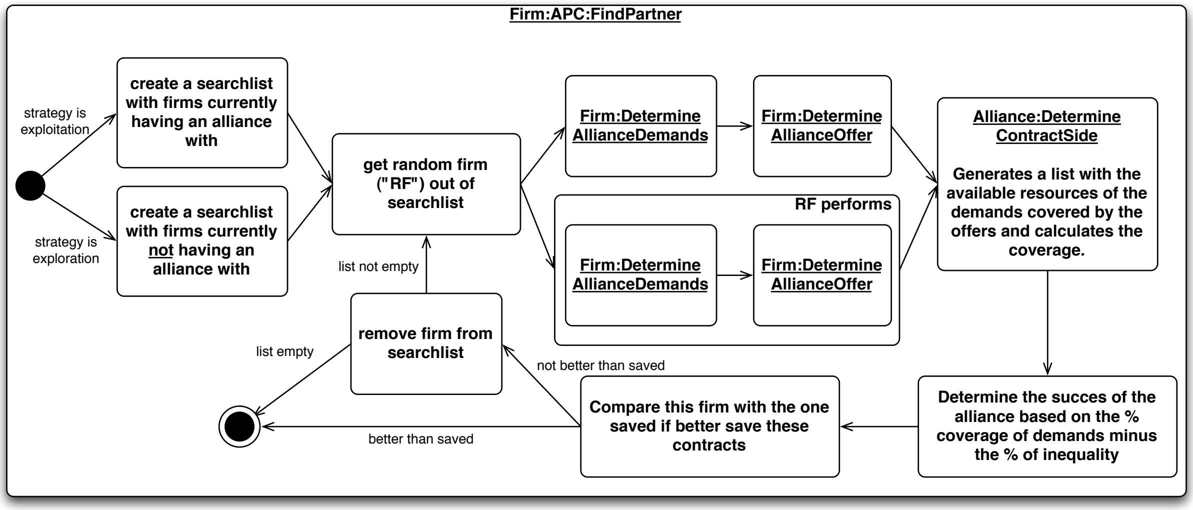


Figure 32 - Code - Firm:APC:FindPartner

The find partner procedure, as shown in figure 33 and code 4, is the second procedure where the strategy of the firm is of importance. Because in the case of the exploitation strategy the find partner procedure is going to look within the current set of alliance partners to find a suitable partner. In the exploration strategy there is searched within the entire set of firms that the firm currently does not have an alliance with. With this list a firm is selected at random and then both the firms determine their demands and offers with these offers and demands the firms create a concept contract this contract contains: (1) the success percentage based on the match of products, (2) the product that the alliance is about (3) the resources that are going to be shared over the alliance and (4) the resources that need to be reserved so that the reason why this alliance is formed is preserved. After this process the inequality is determined by taking the success percentage of coverage of demands, the inequality of resources in percentage of shared resources versus the difference in resources over the complete alliance with that firm.

```
to-report firm-APC-FindPartner [strategy succes]
  let partnercontract [ ]
  let turtle-list [ ]
  set partnercontract lput nobody partnercontract
  set partnercontract lput succes partnercontract
  set partnercontract lput [ ] partnercontract
  set partnercontract lput [ ] partnercontract

  ifelse (strategy = "exploration")[
    set turtle-list sort turtles
    set turtle-list remove (position self turtle-list) turtle-list
    foreach sort [end2] of my-out-links [set turtle-list remove (position ? turtle-list) turtle-list]
  ][
    set turtle-list sort [end2] of my-out-links
  ]
  ;; Removing just generated alliances.
  foreach sort [end2] of my-out-links with [$tie-Strength = 0][
    set turtle-list remove (position ? turtle-list) turtle-list
  ]

  let cont true
  while [cont and not empty? turtle-list][
      set turtle-list shuffle turtle-list
      let current-turtle item 0 turtle-list
      set $alliance-Demand firm-DetermineAllianceDemands global-ListsSubstract $firm-TotalResources $alliance-Shared
      set $alliance-Offer firm-DetermineAllianceOffer global-ListsSubstract
                            (global-ListsSubstract $firm-TotalResources $alliance-Shared) (item 2 $alliance-Demand)
      ask current-turtle [
        set $alliance-Demand firm-DetermineAllianceDemands global-ListsSubstract $firm-TotalResources $alliance-Shared
        set $alliance-Offer firm-DetermineAllianceOffer global-ListsSubstract
                            (global-ListsSubstract $firm-TotalResources $alliance-Shared) (item 2 $alliance-Demand)
      ]
      let contractside-self alliance-DetermineContractSide $alliance-Demand ([$alliance-Offer] of current-turtle)
      let contractside-partner alliance-DetermineContractSide ([$alliance-Demand] of current-turtle) $alliance-Offer

      let inequality 0
      let inequalityperc (sum item 2 contractside-self)
      set inequality inequality + (sum item 2 contractside-self) + (sum item 2 contractside-partner)
      let linkfrom in-link-from current-turtle
      let linkto out-link-to current-turtle
      if (linkfrom != nobody)[
         set inequality inequality + sum (alliance-getResources [$tie-ProductResources] of linkfrom)
      ]
      if (linkto != nobody)[
        set inequality inequality + sum (alliance-getResources [$tie-ProductResources] of linkto)
        set inequalityperc inequalityperc + sum (alliance-getResources [$tie-ProductResources] of linkto)
      ]
      ifelse (inequalityperc > 0)[
        set inequalityperc (inequalityperc / inequality * 100)
      ][
        set inequalityperc 100
      ]
      let cursucces (item 0 contractside-self + item 0 contractside-partner) / 2 - inequalityperc

      if (succes = 0)[
        set succes cursucces
        set partnercontract replace-item 0 partnercontract current-turtle
        set partnercontract replace-item 1 partnercontract cursucces
        set partnercontract replace-item 2 partnercontract contractside-self
        set partnercontract replace-item 3 partnercontract contractside-partner
      ]
      if (cursucces > succes)[
        set succes cursucces
        set partnercontract replace-item 0 partnercontract current-turtle
        set partnercontract replace-item 1 partnercontract cursucces
        set partnercontract replace-item 2 partnercontract contractside-self
        set partnercontract replace-item 3 partnercontract contractside-partner
        set cont false
      ]
      set turtle-list remove-item 0 turtle-list
  ]
  report partnercontract
end
```

Code 4 – firm-APC-FindPartner

In the find partner procedure two important procedures are used; (1) to determine the alliance demands, see figure 34 and code 5, and (2) to determine the offer to the other firm, see figure 35. Both use the already discussed calculate production. In the first case to determine what resources are needed to create additional value, in the second case to make sure that there are no left opportunities and specify that the remaining resources can be used to form alliances with.

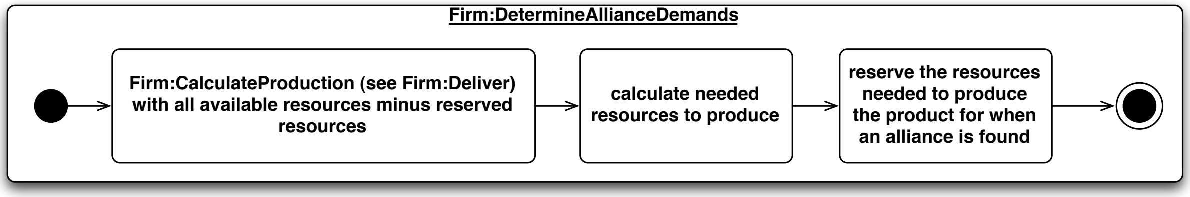


Figure 33 - Code - Firm:DeterminceAllianceDemands

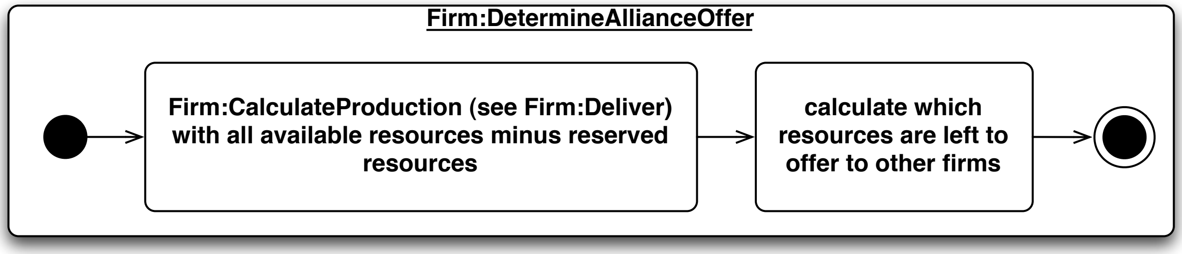


Figure 34 - Code - Firm:DetermineAllianceOffer

```
;;
to-report firm-DetermineAllianceDemands [resources]
  let product -1
  let products [ ]
  let demands [ ]
  let production firm-CalculateProduction resources

  ifelse ($firm-Strategy = "exploitation") [
    set products global-SortedListsMaxMinPositions sort-by [?1 > ?2] production production  ;;large to small
  ][
    set products global-SortedListsMaxMinPositions sort-by [?1 < ?2] production production  ;;small to large
  ]

  ;; If there are more than one items in the list we should pick one of the products in the list at random.
  set product item 0 (shuffle products)
  set demands lput product demands

  let demanded-resources [ ]
  let reserved-resources [ ]
  let run1 0
  while [length resources > run1][
    let requirements matrix:get-row [$patch-ProductRequirements] of patch-here product
    ifelse (item run1 requirements - item run1 resources > 0)[
      set demanded-resources lput (item run1 requirements - item run1 resources) demanded-resources
      set reserved-resources lput (item run1 resources) reserved-resources
    ][
      set demanded-resources lput 0 demanded-resources
      set reserved-resources lput (item run1 requirements) reserved-resources
    ]
    set run1 run1 + 1
  ]

  if (sum demanded-resources = 0)[
    set demanded-resources matrix:get-row [$patch-ProductRequirements] of patch-here product
    set reserved-resources $global-EmptyResourceList
  ]

  set demands lput demanded-resources demands
  set demands lput reserved-resources demands
  if (firm-label = "fav-product")[
    set label product
  ]
  report demands
end
```

Code 5 - firm-DetermineAllianceDemands

APPENDIX C: SIMULATION INTERFACE

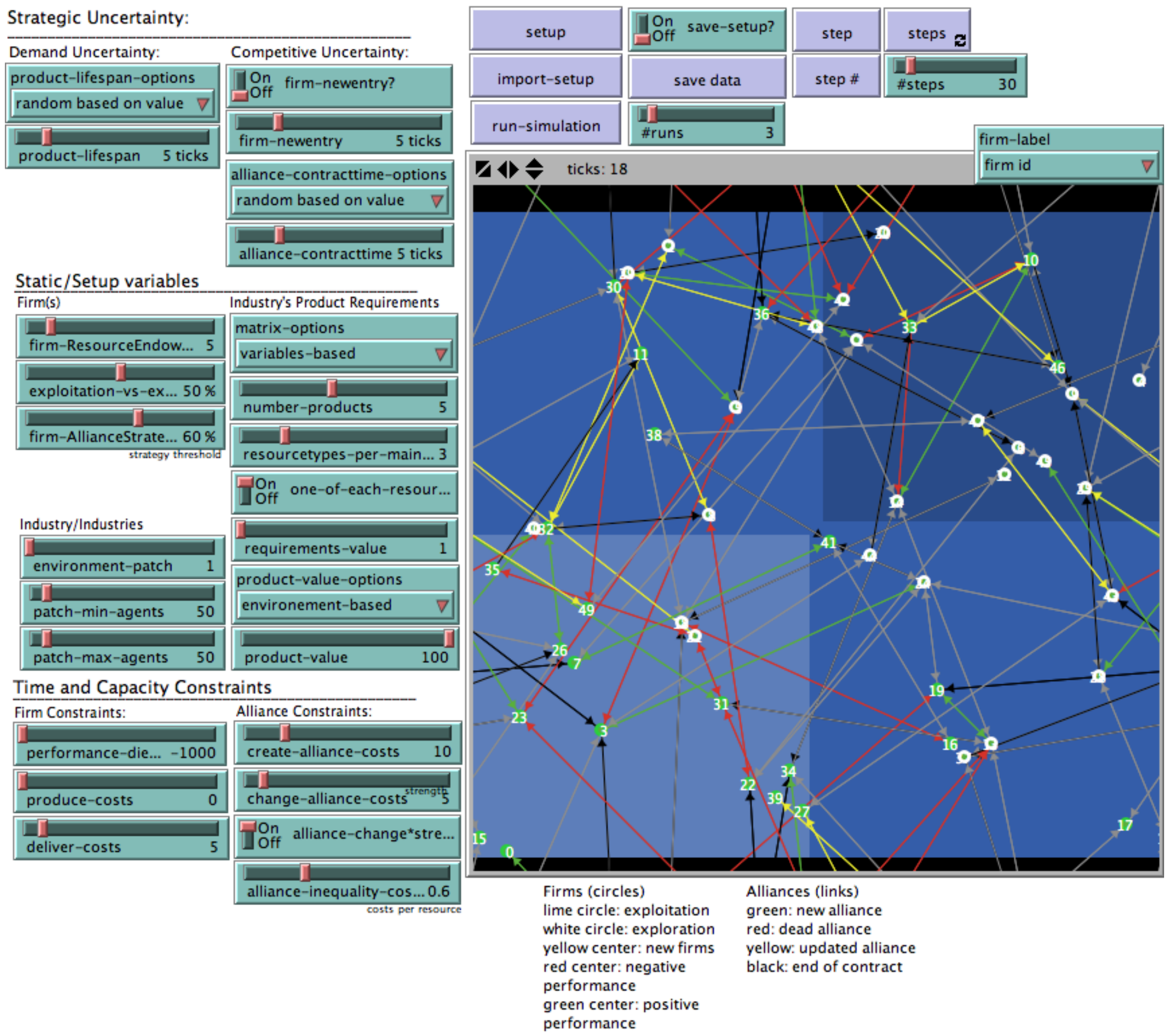


Figure 35 - Simulation interface (1/2)

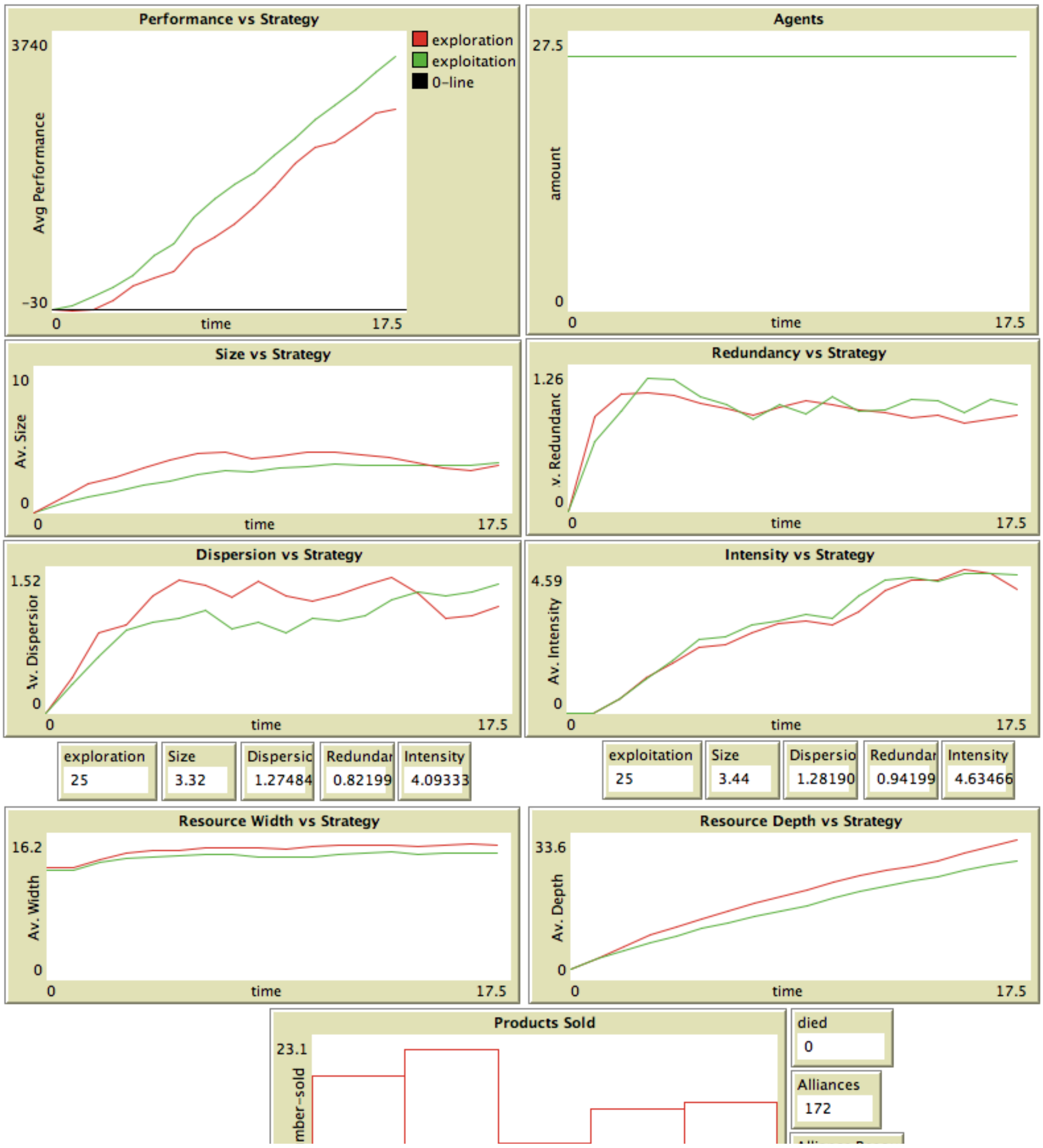
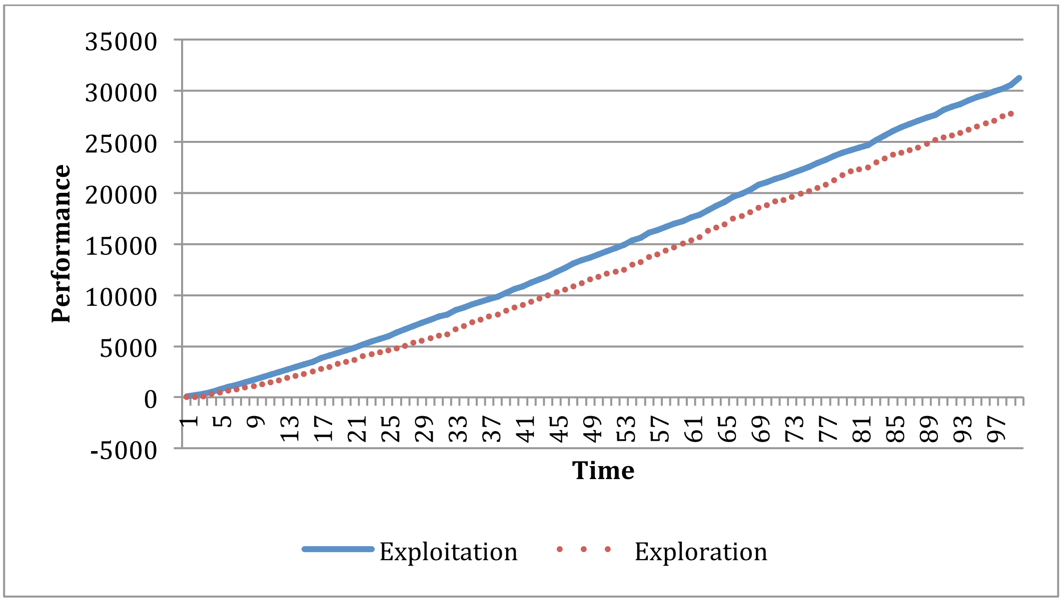


Figure 36 - Simulation Interface (2/2)

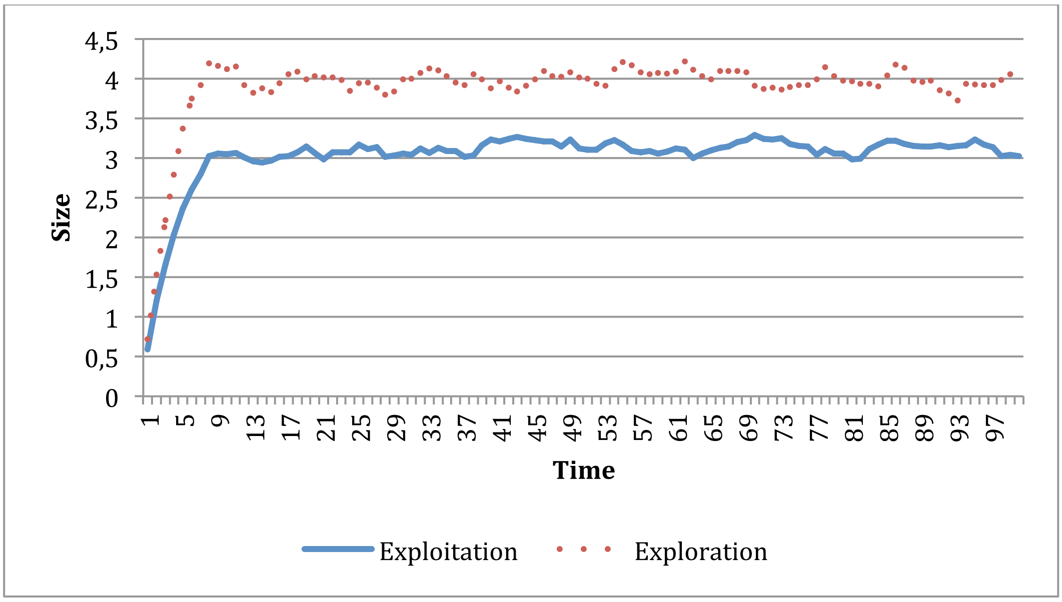
Appendix D: Generated Data

Test Case 1 "Uncertain" - Average Overview

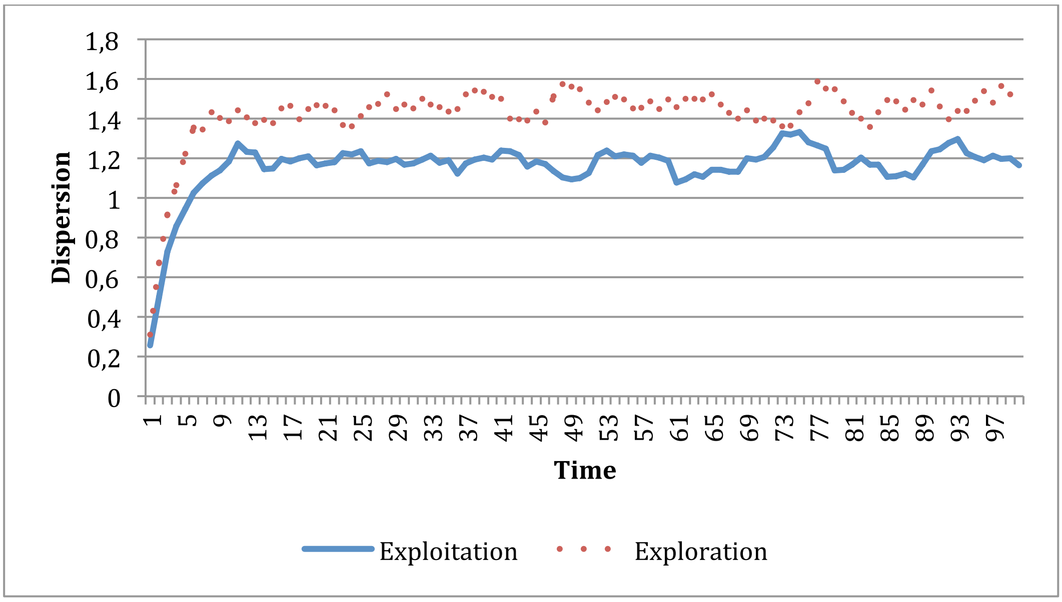
Performance **Student T-Test: 0,074**



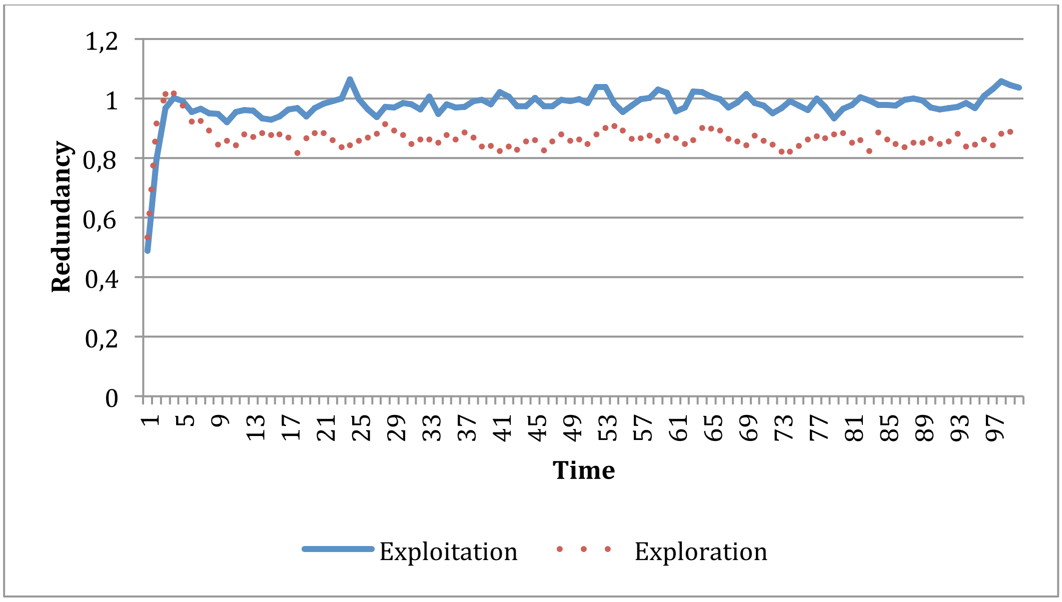
Size **Student T-Test: 6,61E-33**



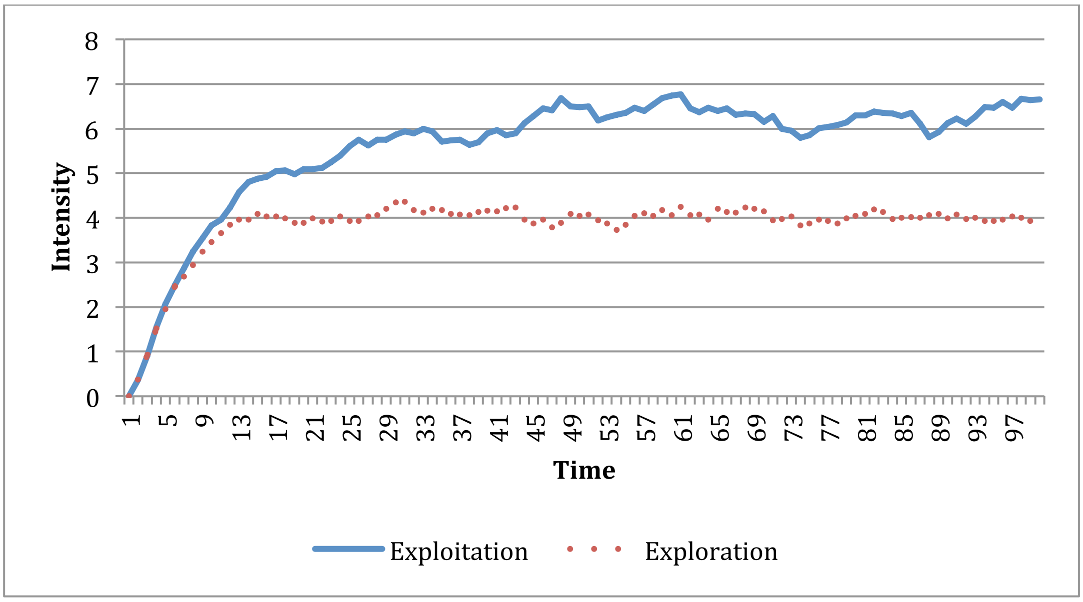
Dispersion **Student T-Test: 4,72E-27**



Redundancy **Student T-Test: 1,53E-33**

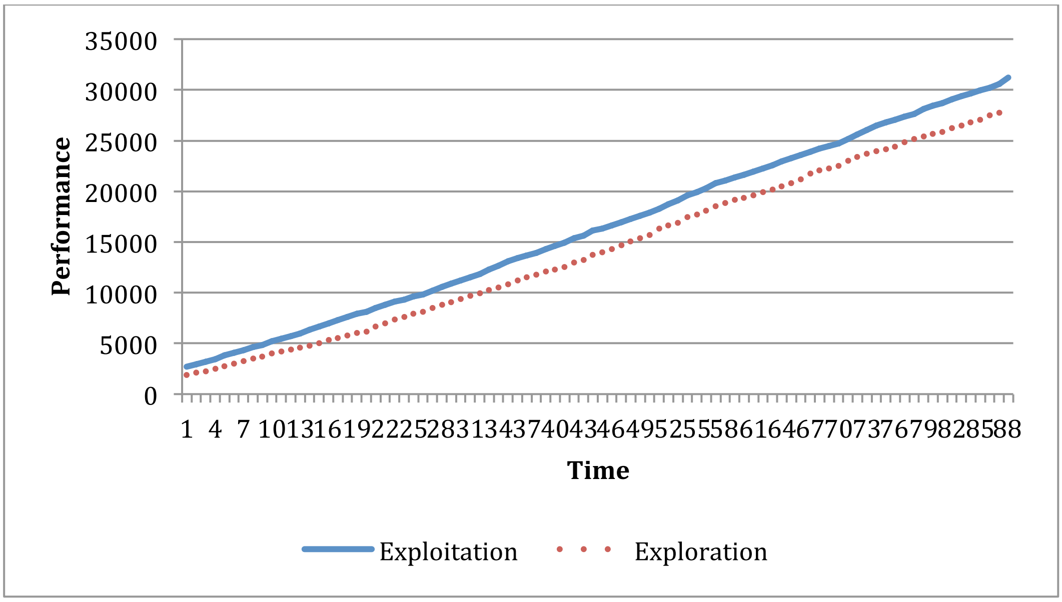


Intensity **Student T-Test: 3,82E-24**

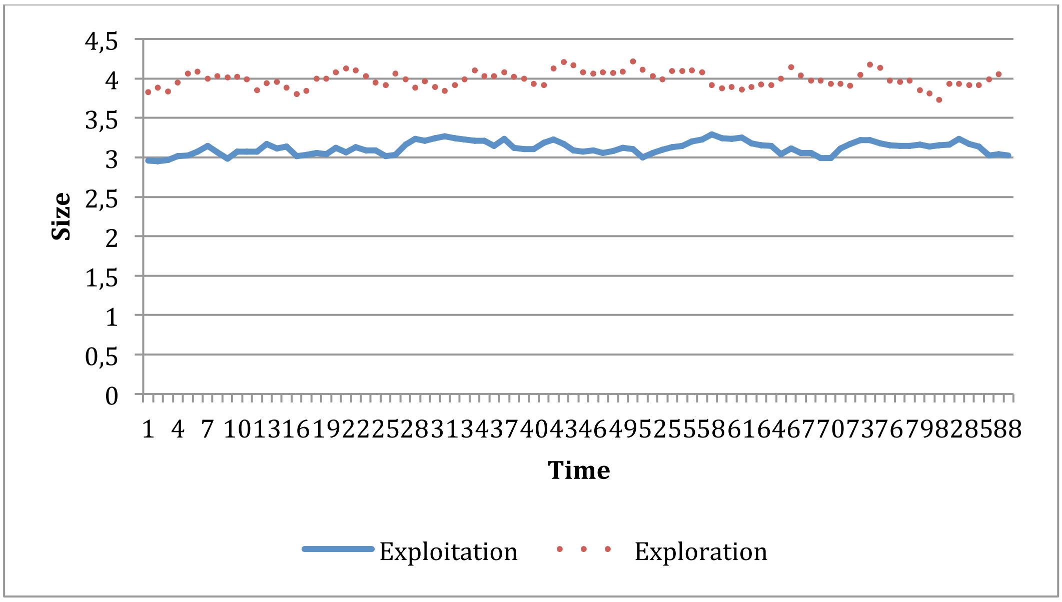


Test Case 2 "Uncertain" - Average Overview – 15 to 100

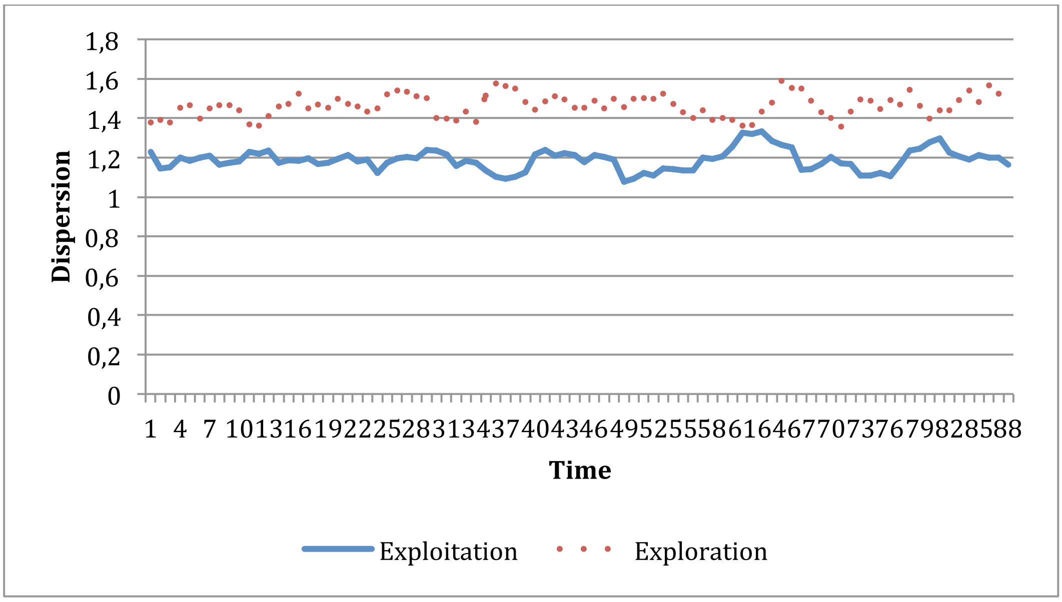
Performance **Student T-Test: 0,050**



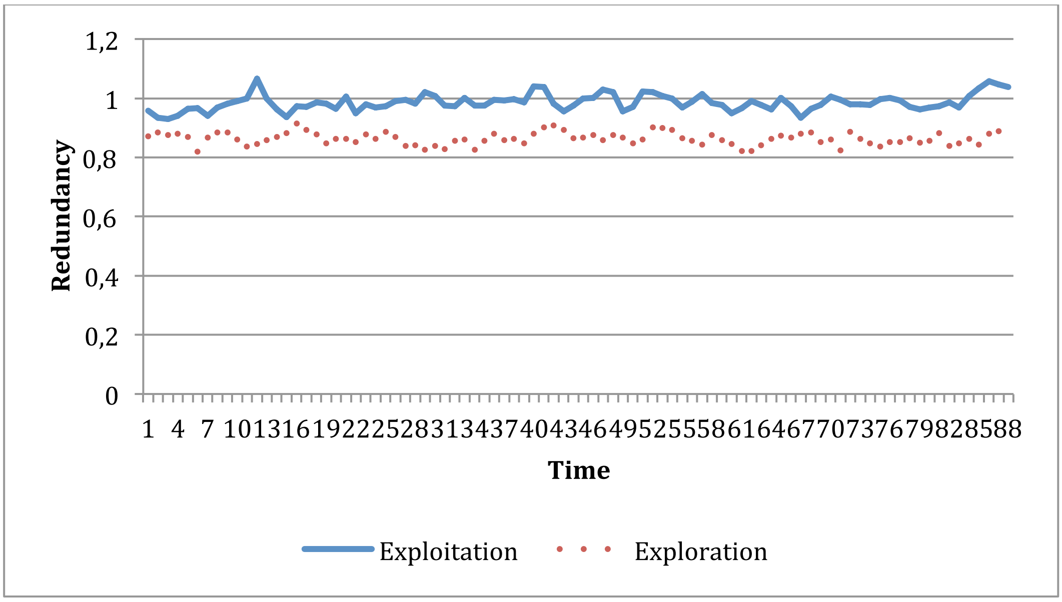
Size **Student T-Test: 8,79E123**



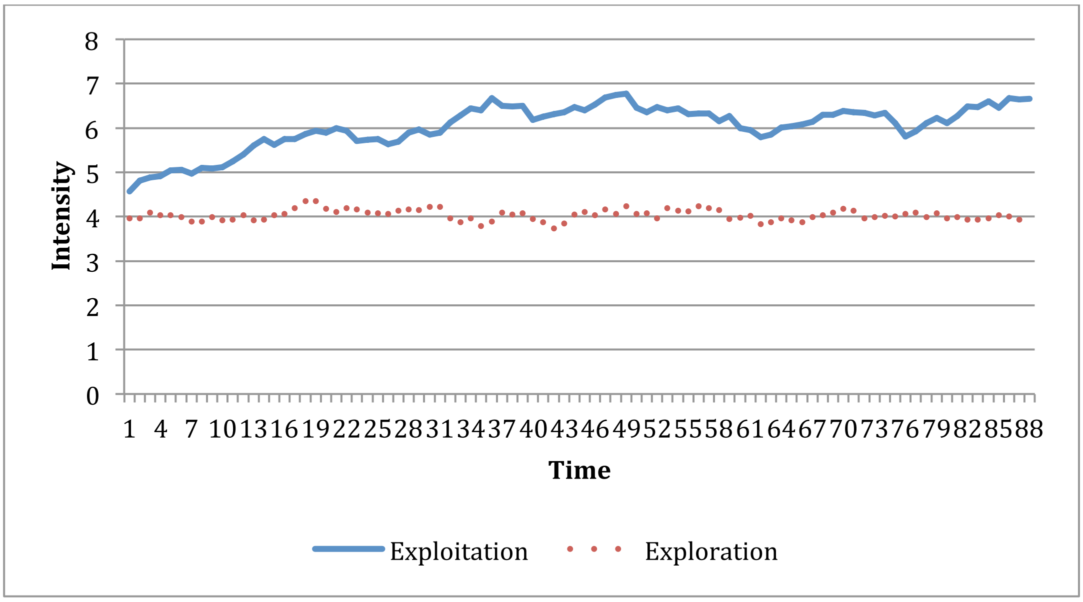
Dispersion **Student T-Test: 2,67E-78**



Redundancy **Student T-Test: 8,66E-78**

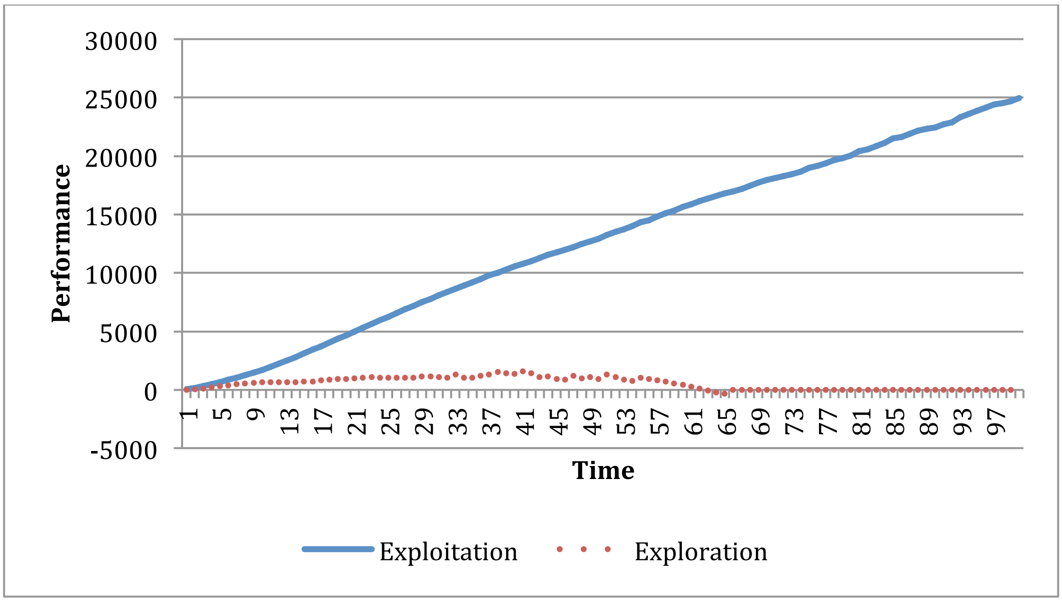


Intensity **Student T-Test: 2,30E-83**

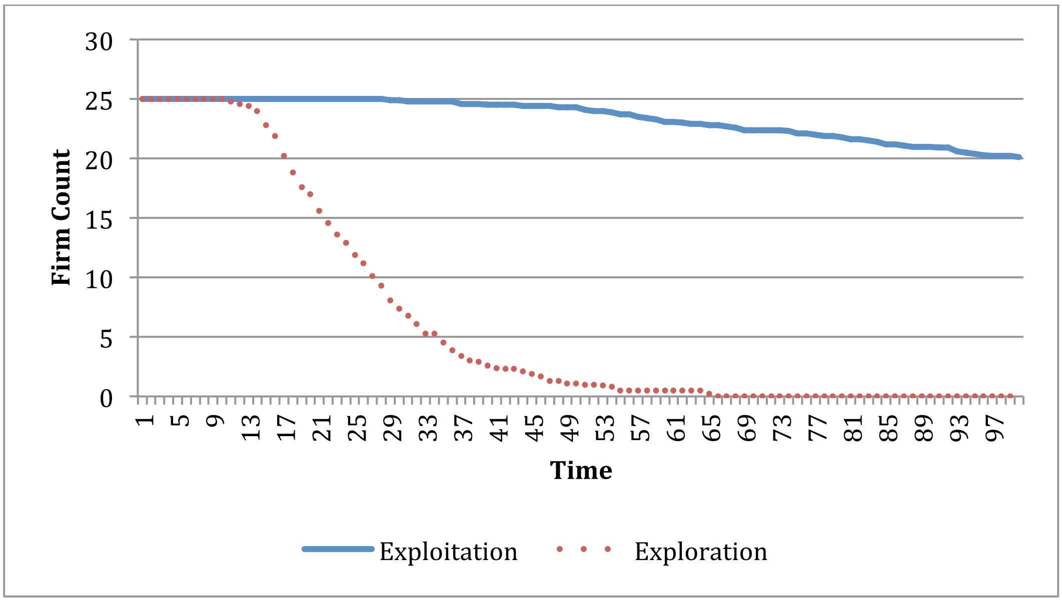


Test Case 2 "Certain" - Average Overview

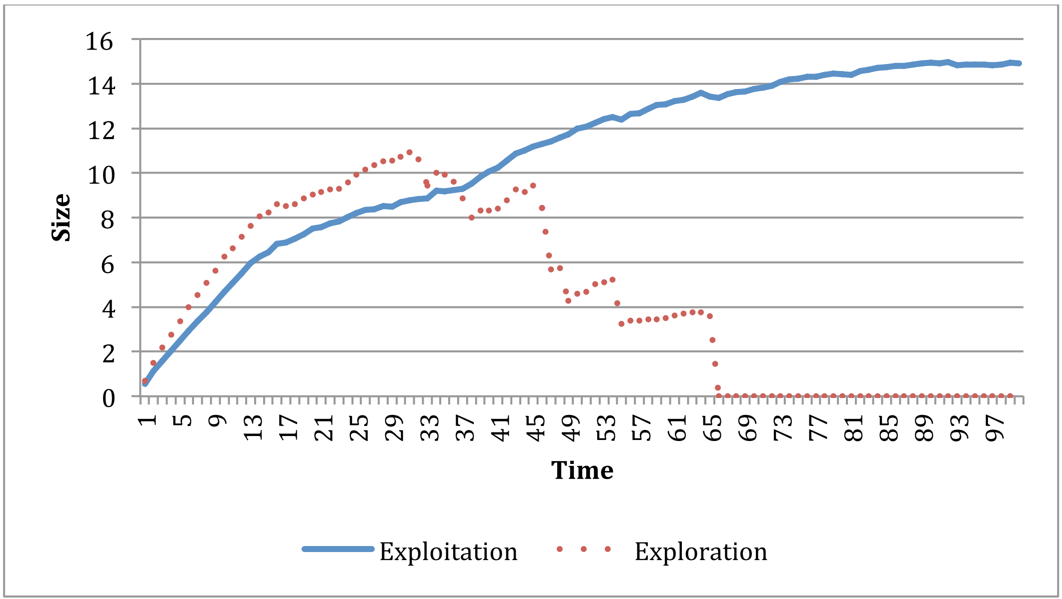
Performance **Student T-Test: 7,40E-39**



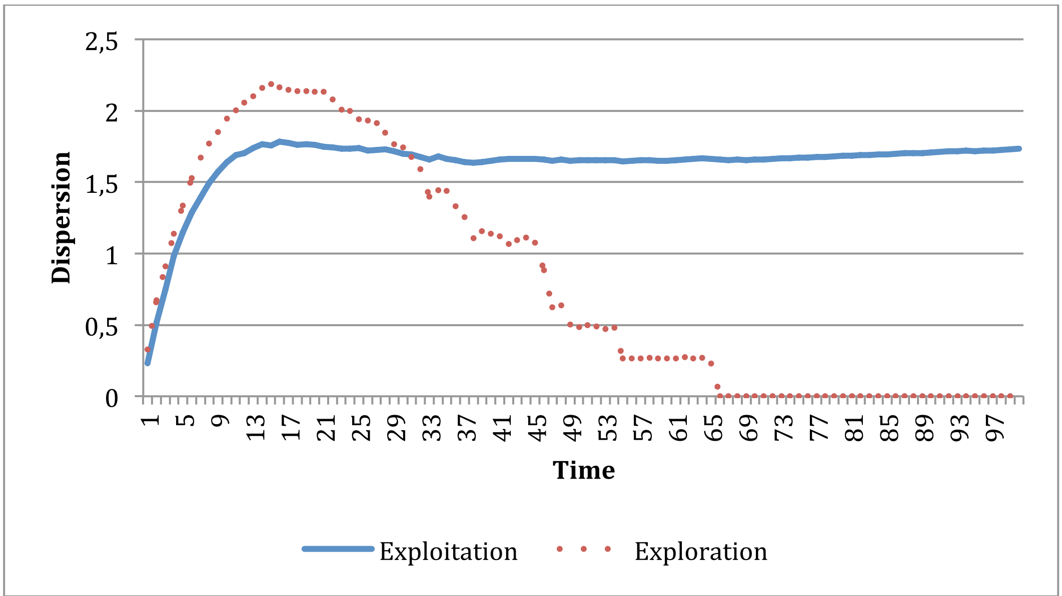
Agents **Student T-Test: 3,87E-44**



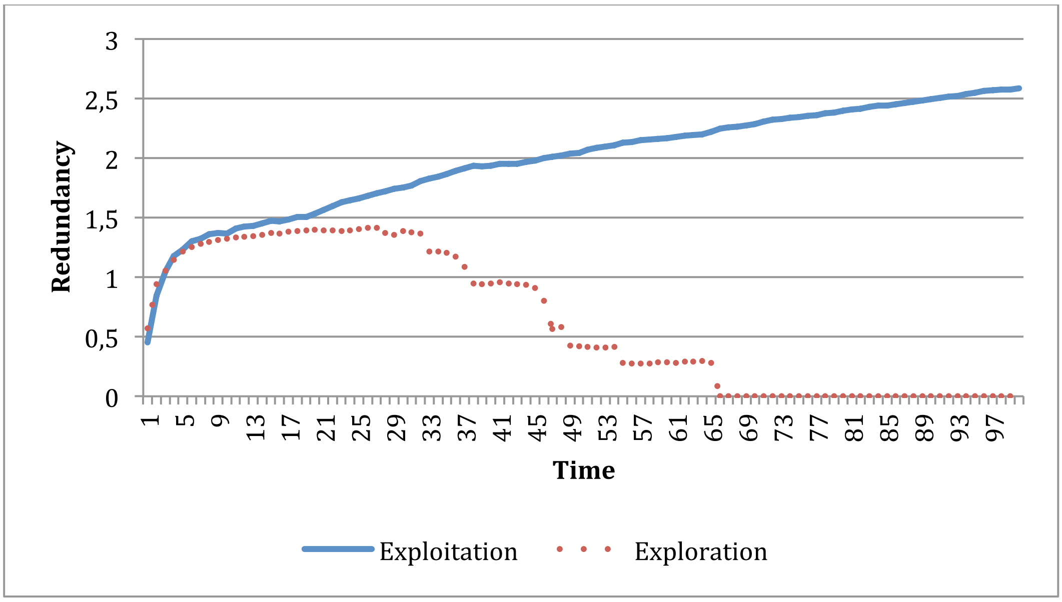
Size **Student T-Test: 1,1E-23**



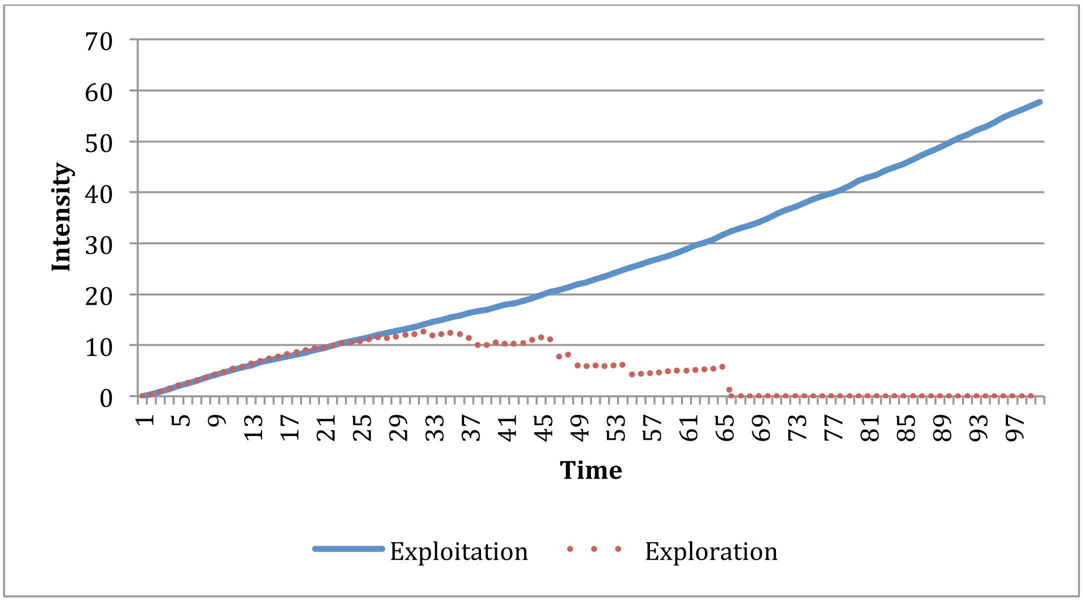
Dispersion **Student T-Test: 9,45E-19**



Redundancy **Student T-Test: 7,83E-46**

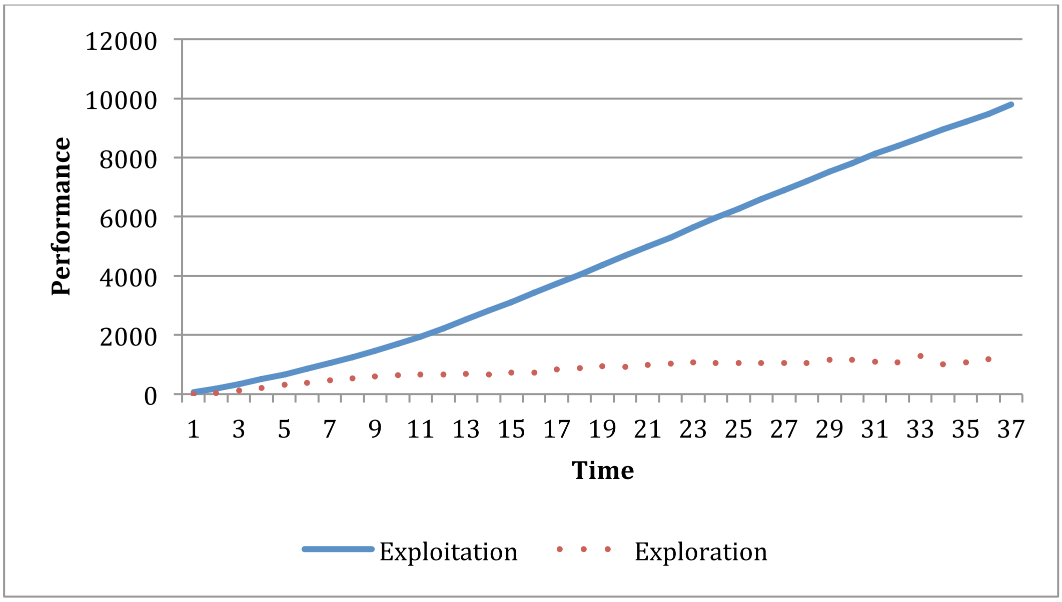


Intensity **Student T-Test: 3,16E-25**

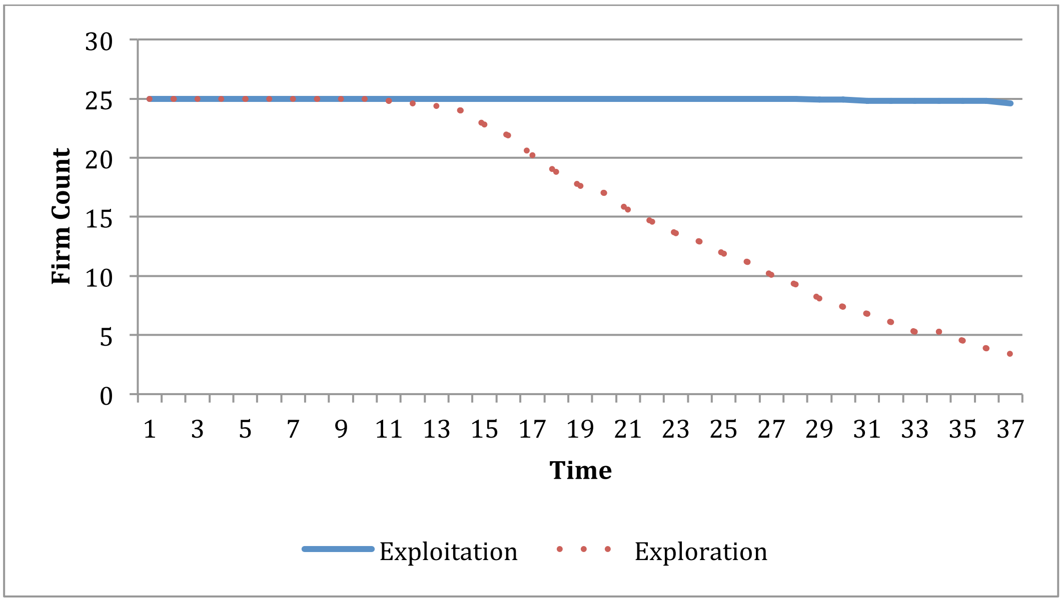


Test Case 2 "Certain" - Average Overview – 0 to 36

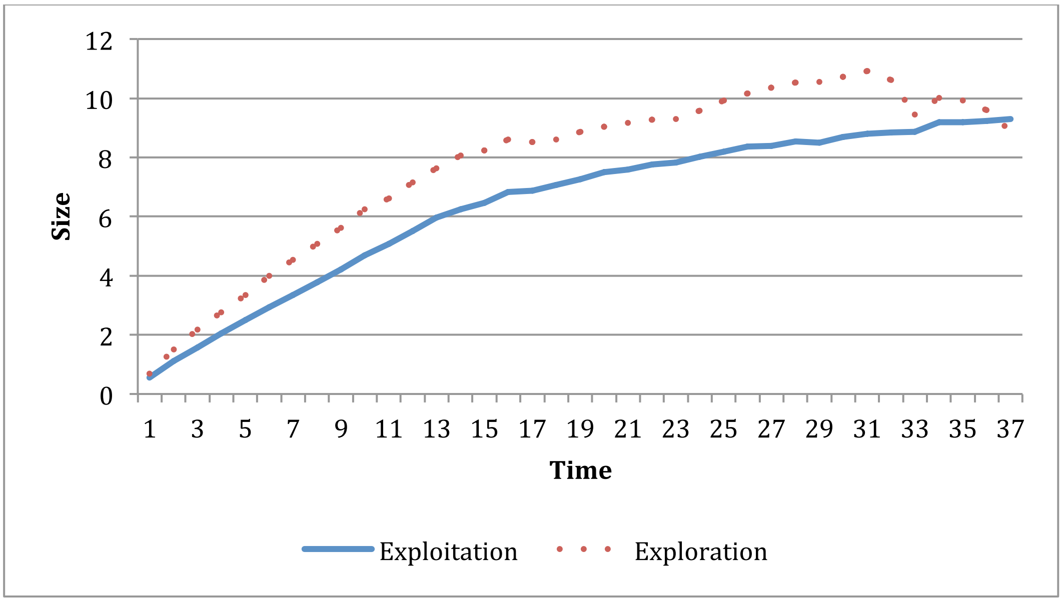
Performance **Student T-Test: 1,74E-10**



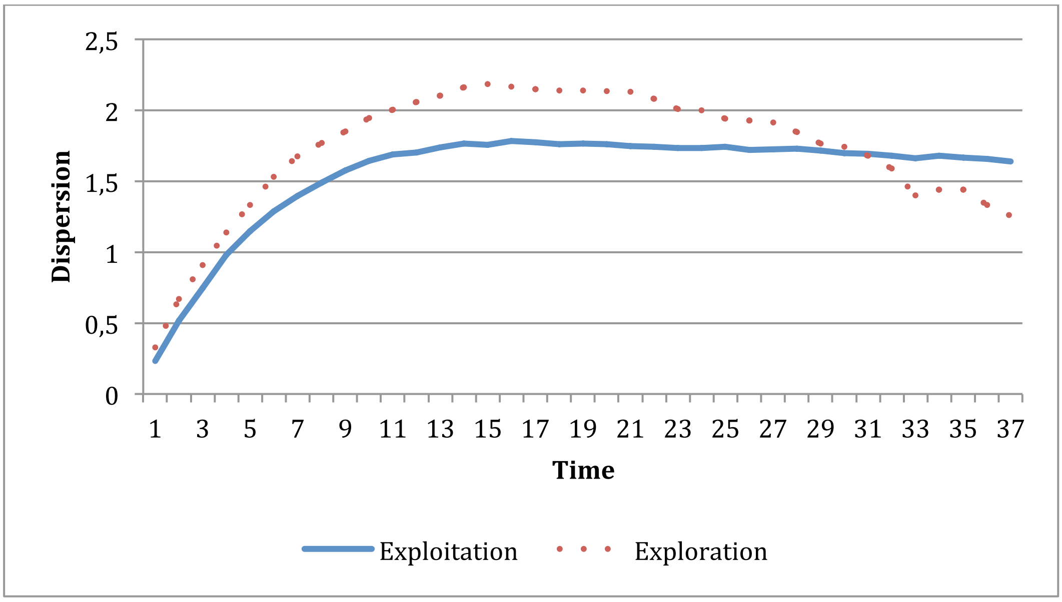
Agents **Student T-Test: 1,06E-08**



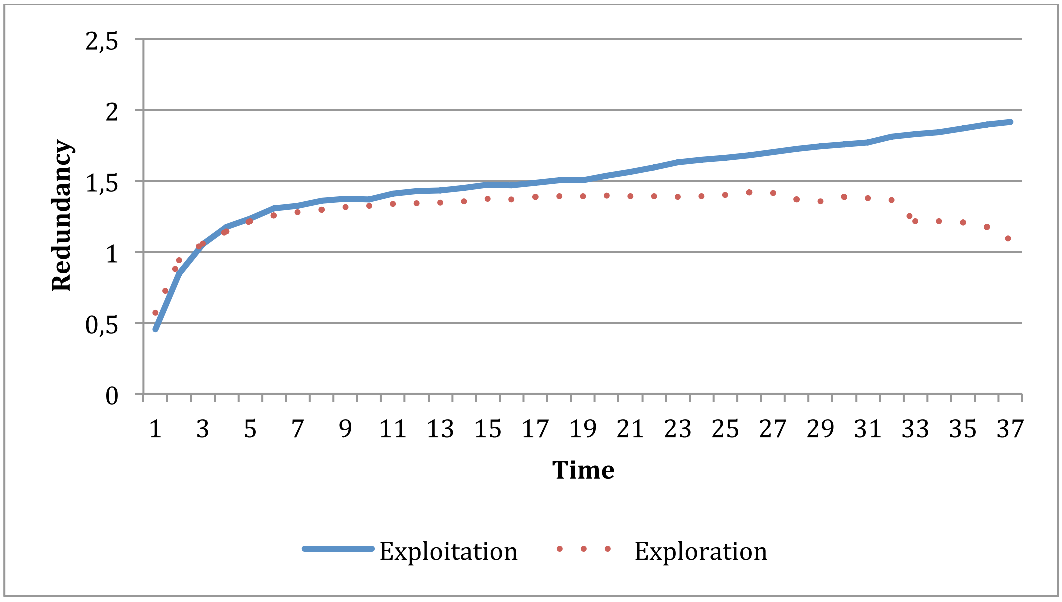
Size **Student T-Test: 0,012**



Dispersion **Student T-Test: 0,037**



Redundancy **Student T-Test: 9,63E-05**



Intensity **Student T-Test: 0,300**