STS 09038
Examensarbete 30 hp
Oktober 2009

BRIDGE

A model for future research in Europe

Daniel Berggren
Johan Gillhagen

UPPSALA
UNIVERSITET

Teknisk- naturvetenskaplig fakultet
UTH-enheten

Besöksadress:
Ångströmlaboratoriet
Lägerhyddsvägen 1
Hus 4, Plan 0

Postadress:
Box 536
751 21 Uppsala

Telefon:
018 – 471 30 03

Telefax:
018 – 471 30 00

Hemsida:
http://www.teknat.uu.se/student

Abstract

BRIDGE - En modell för framtida forskning i Europa

BRIDGE - A model for future research in Europe

Daniel Berggren & Johan Gillhagen

This thesis evaluates the Bridge model, an initiative from the European Union for structuring research in Europe. The model aims to combine expertise from academia and industry to create an effective interaction that stimulates innovation. This expertise will be geographically spread across Europe, which means that Bridge will serve as a network with virtual subunits.

The authors examine the model with two approaches. First, Bridge is analyzed from a theoretical perspective to study its potential as a network with virtual organizations. Further theoretical framework makes an extensive survey of the organization and its components.

Second, Bridge is analyzed by implementing the model in simulation software in order to identify important and sensitive elements of the model. Runs of the simulation display component connections and parameter settings that optimize Bridge's force of innovation.

The report notes that Bridge meets the theoretical requirements for becoming a successful network with virtual organizations. The simulations also show that Bridge should finance their projects without interference from other parties. Given this scenario, the authors identify a number of components that Bridge should emphasize in order to effectively generate innovations.

Handledare: Paul Beatus
Ämnesgranskare: Bengt Sandblad
Examinator: Elisabet Andrésdóttir
ISSN: 1650-8319, STS 09038

Populärvetenskaplig beskrivning

Europa har länge varit placerat i fronten för världens teknologiska utveckling. Med en ökad globalisering och intensifierade marknader så är denna placering inte längre självklar. För att upprätthålla sin konkurrenskraft på den internationella vetenskapliga arenan, så har EU-komissionen vidtagit åtgärder för att stärka innovationskulturen i Europa.

Ett av dessa initiativ är *Bridge*, en modell som syftar till att stimulera interaktionen mellan kompetenser i den akademiska och den industriella sfären. Modellen svarar för ett nytt sätt att bedriva forskning på i Europa; nämligen att genom stimulans av akademiskt och industriellt samarbete skapa så kallade *virtuella organisationer*. Dessa virtuella organisationer kommer att bestå av akademiska och industriella medlemmar, vars geografiska placering är spridd över hela Europa. Tillsammans utgör medlemmarna delar i forskningsprojekt, med målet att resultera i vetenskapliga innovationer. Den virtuella karaktären hos organisationerna (forskningsprojekten) utgör en central fråga för Bridge, då den sätter okonventionella krav på hur modellen bör formas.

Examensarbetet granskar och utvärderar modellen Bridge med två metodologiska angreppssätt. Först så analyseras Bridge med hjälp av teoretiska ramverk för att studera modellens potential som ett nätverk med virtuella organisationer. Vidare så granskas modellen genom en kartläggning av dess struktur och en implementering av strukturen i simuleringsverktyget Netlogo. Med hjälp av modellsimuleringar så kan författarna identifiera modellkomponenter som är av stor vikt och har hög känslighet. Simuleringarna visar slutligen på parametriska modellinställningar som ger Bridge en hög grad av innovationskraft.

Rapporten konstaterar att Bridge uppfyller de teoretiska krav som ställs för att modellen skall kunna generera ett framgångsrikt nätverk med virtuella organisationer. Resultaten av simuleringarna visar även att Bridge bör finansiera sina forskningsprojekt utan bidrag från externa aktörer. På det sätt som modellen är formulerad så ger en självfinansiering det bästa scenariot gällande innovationskraften hos Bridge.

Table of content

Chapter 1

Introduction

Europe is one of the leading forces in the world regarding research and technology. With an increased global competition and intensified markets, initiatives are made to ensure Europe's force of innovation. One of these initiatives is Bridge, a model that aims to stimulate interactions between competencies from academia and industry. This collaborative model suggests a new way of performing research in Europe. Bridge is designed as a virtual research institute with its members spread throughout Europe. The virtual aspect is a central issue for Bridge, as it formulates unconventional demands on the organization. These demands need to be addressed by Bridge in order for the model to be prosperous.

This thesis will identify the demands and evaluate Bridge's potential as virtual research institute. It will also evaluate the structure of the Bridge model, and advocate considerations on influential model components. The evaluation will be done by using two different tools; theoretical frameworks and simulation software.

1.1 Aim

The aim of this master thesis is to map the Bridge organization and identify critical elements in their model. This will be done in two parts. The aim of the first part will be to evaluate Bridge and its potential as a successful network with virtual organizations.

In the second part there will be a simulation of the Bridge model, displaying component correlations that are essential for an innovative environment. The aim of the simulation will be to provide guidelines for Bridge on how to give structure to their model.

1.2 Research questions

To give answer to the aim of the master thesis, a number of questions are addressed. The first one goes as follows:

Does Bridge fulfil the demands of a successful virtual network according to the VOSTER theory?

If the demands given in the VOSTER theory are met by Bridge, there will be a solid model foundation to base the simulations on. With this scenario, a new question arises:

Which parameters in the Bridge model have a significant sensitivity?

A parameter is sensitive if it displays a significant impact on the results of the model simulation. When the sensitive parameters of the model are identified, a final research question can be formulated:

Regarding the two funding strategies of the model, which scenario gives the optimal results for an innovative environment in Bridge?

1.3 Delimitations

Due to the vast complexity of the Bridge model, some components have been left outside of the simulation. These components will be addressed in the first part of the report, and will work as a complement to the simulation. The components that have been excluded from the simulation are the Bridge board, the scientific council and parts of the executive office (the educational program).

There are further delimitations made when constructing the model in the simulation, but these will be addressed in the simulation part of the report.

1.4 Method and disposition

In order to study Bridge´s potential as a network with virtual organizations, a comparison is made with VOSTER – an existing theoretical framework on the subject. The comparison examines if Bridge holds the key positions of a prosperous network, pointed out in the VOSTER theory. VOSTER is chosen because it constitutes one of the most thorough studies on the subject of virtual organisations

Henceforth, a cognitive work analysis combined with Kimball's and Digenti's framework on virtual teams provides an extensive mapping of the Bridge organization. This illustration of Bridge works as a complement to the model components that are included in the simulation.

The simulation is based on a projection of Bridge, where critical elements of the model are operationalized into computable components. Component interactions and parameter values in the model are based on empirical studies. These studies include qualitative interviews and observations of statistics. The subjects of the interviews are scientists, geographically spread throughout of Europe. Their input helps the authors to validate assumptions that are made for the model-projection. The statistics are obtained from various universities and technology transfer offices situated in different parts of Europe.

The simulation is performed in the software Netlogo, where the model is implemented in a system dynamic modelling tool. This application is chosen due to its graphical simplicity and its ability to construct large socio-technologic dynamic systems. Thus it is suitable with the complex model that is Bridge.

A sensitivity analysis of the simulation model displays the components' impact on the results. The sensitivity analysis indicates which components that should be taken into consideration when Bridge applies their model to actual use.

Last, simulation runs are made to identify which scenario that provides the optimal results for an innovative environment in Bridge.

Chapter 2

Previous research and theory

2.1 Guidelines for virtual organizations[1]

In 2001 the European Union funded a project called *Virtual Organizations Cluster* (VOSTER). The project's aim was to collect, analyse and synthesize the results from a number of leading European research projects on Virtual Organisations (VO's), i.e. geographically distributed, functionally and culturally diverse, dynamic and agile organisational entities linked through information and communication technology.

The project ended in 2004 with a report called "Guidelines for Virtual Organizations", and since Bridge can be seen as a virtual organization, we have chosen to take a closer look at this report.

The reports' definition of a network is:

"A network / source network is a more stationary, though not static, group of organizational entities, which have developed a preparedness to cooperate in case of a specific task / customer demand".

A network can be seen as a stable set of companies that are prepared to set up temporary Virtual Organizations/Enterprises to address specific business opportunities**.** The network constitutes the platform that builds up the foundation for all projects carried out by the individual members within the network. For every business opportunity that arises, different members of the network are assembled to carry out the project. Sometimes the term "breeding environment" is used for a network to emphasise its importance as a basis for VO activities.

2.1.1 Key members of the network

To get a network to function efficiently, the authors point out a few important positions within the network that are important to have. These key positions will lay the foundation for the network:

2.1.1.1 Broker

The broker's tasks are essential to the network. *He/She* is responsible for bringing in new business opportunities into the network and getting potential customers to meet with the network. Although the broker's role is an important one, the network members still need to put in a lot of effort of their own to make the network a successful one.

[1] "Guidelines for Virtual Organizations", VOSTER project, p. 5-15 and 20-21

2.1.1.2 Manager In-/Outsourcing

This person acts like an interface between the network and the participating companies of the network. *He/She* shapes the communication between the partners and contributes with know how and resources to the network, and in particular to concrete projects.

2.1.1.3 Network Coach

The network coach has some similarities with the manager in-/outsourcing, though the network coach is more neutral. *He/She* is not related to a specific company or business opportunity. His/hers role is to maintain a functional co-operative network culture which will lay the foundation for all future endeavours. To achieve this goal the network coach must coach the members, set rules, manage relationships and provide for technological infrastructure.

2.1.1.4 Auditor

The auditor ensures the financial stability in the network. Its roles are neutral and the auditor has the financial control of all operations. He/She interacts with the customers and banks in most financial matters.

2.1.1.5 Leadership team

This team is represented by the CEO's of the network companies. Its role is to generate the network strategy and its alignment.

When all of the above posts are fulfilled, then there is a foundation for the network. From now on the network is ready to engage in business opportunities, and often it is the broker that identifies the business opportunities first.

If a business opportunity arises, the next big step is to form a business model. This model describes the business concept, business activities, a finance model and the responsibilities and compensations for the participating partners. It's important to make this business model, since when it's done, you get a clear view whether the business opportunity is worthwhile taking. If it is worthwhile, the next step is to form a virtual organization for the business opportunity.

2.1.2 Key members of the VO/project

The VOSTER project's definition of a virtual organization is stated below:

"Virtual organization / Virtual Enterprise is a temporary consortium of partners from different organizations established to fulfil *a value adding task*, for example a product or service to a customer. The lifetime of a VO is typically restricted: It is created from the network for a definite task and dissolved after the task has been completed".

Much like the network, there are a number of key positions that lay the foundation for the VO, and they are presented in the sections below.

2.1.2.1 Business Architect / Competence Manager

He/She is in charge of developing the business model, in other words he/she configures the project. Furthermore, the business architect/competence manager is responsible for bringing the partners' competencies together.

2.1.2.2 Project Team

The project team is the core of the whole project, since the project team includes all the employees of the participating partners in the ongoing project. The team is set up so that the project goal will be fulfilled, and therefore the project team should cover all relevant project functions. Since the project could consist of partners with widely different company cultures, it is important to have ground rules and coaching to ensure that the work goes on smoothly to avoid conflicts.

2.1.2.3 Project Manager

Responsible for the whole project is the project manager. He/She supervises the ongoing work, organizes the activities within the project and plans the budget and resources. Furthermore, he/she is the contact person to the customers, and therefore the project manager needs to be a skilled person on many different areas. He/she needs to have authority, and may have to replace certain parts of the project team/partners to see to that the project runs as planned.

2.1.3 Guidelines for the network

Start up phase

In the start up phase of the network, it is important to have a clear vision and aim to identify the overall purpose. In this phase the extent of the network should be defined, examples of those variables could be:

- Which type of markets to address
- Which type of products to address a market
- Which type of competencies the partners should have to satisfy the identified needs

When this identification process comes to an end, there will be a well defined overall purpose of the network. This purpose, together with including all key members, will create a solid network foundation that can generate successful virtual organizations.

2.2 Leading virtual teams that learn[2]

In the book "Leading virtual networks that learn" the authors implement a model, which is meant to describe the lifecycle of a virtual network. We will include seven steps of the model. These steps constitute different dimensions that need to be addressed in order for the virtual network to be successful. The remaining steps of the model are not relevant for the type virtual teams that Bridge will form. These steps concern learning processes on an individual level in virtual organizations and are therefore too detailed.

The seven chosen steps of the model are stated below:

- Establish the team's purpose
- Determine team roles
- Make the whole visible
- Provide "line of sight"
- Choose the right media
- Communicate frequently
- Contract for active participation

We will now describe each dimension for each stage more thoroughly. First off is the Initiating stage, where a base for the virtual team is created.

2.2.1 Establish a team's purposes

Previous research on virtual teams and networks have all shown that an important factor for being successful is having a shared purpose around which everyone is aligned. This will contribute to establishing a unified virtual network, where members of the virtual team all feel like they are purposeful. To create this kind of "collective mind", more is needed than just an agreement for all members on the global scale. In addition to the overall goals, the team should also have smaller goals that are achievable early on in the team's existence. This will lead to a development of trust between the members, since coming through with an achievement will make you trustworthy in future tasks as well. The subtasks provided on an early stage should be meaningful to the overall project, but not necessarily difficult or time-consuming. An example could be that each member explores available communication tools and set up profiles for these tools in terms of accessibility, team preferences and where it might be used.

2.2.2 Determine team roles

It is important when establishing a team to avoid an overdependence on the leader. This might lead to the leader playing out all the needed roles in projects, and will make the team weak with a potential leader burnout.

Roles are more complex in a distributed team, because there are more roles and potentially new unfamiliar roles here as opposed to the situation in a traditional

[2] "Leading Virtual Teams that Learn", Kimball and Digenti, p. 5-24

network. There should be continuous discussions and negotiations of roles in the virtual network, and a reconfiguration of roles further on in a project could make more sense than the initial set of roles. To summarize, virtual teams need to spend a lot of time being explicit as to what is expected from leaders, managers and members. The situation in a virtual network will often be a new one for the people involved, and unfamiliar dynamics of interaction can lead to misunderstandings and frustration.

2.2.3 Make the whole visible

One major problem that virtual networks often are confronted with is that it can be difficult to maintain an image of the team as a whole. If the virtual team does not look at itself as a unit, the members might feel they are a part of just a loose collection of related parts. This affects the teamwork negatively, since being able to work as a whole is what makes a team powerful.

There are many different strategies that can be used to ensure the team image as a whole. For example this can be done with graphical representations of the virtual team.

2.2.4 Provide "line of sight"

In a virtual network it is important that the team members are able to "see" and "hear" what is happening around them in the organization. The authors describe this as a "line of sight", without which the members can feel disconnected and this reduces their effectiveness. In many virtual teams, the leader is the only one with a good overall view of a project's progress. It is therefore critical that the leader shares the information with all the members, and that they are enabled to be in direct contact with each other. The line of sight is particularly important in smaller teams, when there is a critical mass of members located somewhere else. The smaller teams need to feel that they are "in the loop" and that they are not missing out on relevant progress in the project.

2.2.5 Choose the right media

The virtual network must, at an early stage, negotiate their preferences regarding the use of different communications media. When choosing a media there are several factors that might come into play; habits, previous experiences, cognitive style and so on. Cross-cultural teams might also have to consider different time zones and language issues.

In general, virtual teams that employ a diversified repertoire of communication tools are more powerful. Furthermore, a successful team should implement synchronous (face to face) methods in their communication. This way of communicating will generate more attention and energy for shorter periods of time.

2.2.6 Communicate frequently

When communicating in virtual networks, there is always a risk that actions or information can be misinterpreted. For example, if an email is sent and there is no response to this email, the lack of response could derive from numerous of reasons (the receiver could be away, the receiver has not actually received the email, or the receiver simply does not understand the information in the email). There is a tendency for members in a virtual team to assume the worst-case explanation when there is no response, and to be reluctant to pursue the issue for fear of appearing insecure. This can lead to misunderstandings being left unresolved, which undermines the feelings of trust that are necessary for a good team performance. Therefore it is important to establish team agreements about norms for response in various media. These agreements should include how the receipt of a message will be acknowledged. There should also be agreements for the expected frequency of posts, rules for peripheral participation (reading but not contributing) and so on.

2.2.7 Contract for Active Participation

In virtual teams it is a great challenge to ensure team members devotion and active participation in current agendas. Therefore, virtual team members need to learn how to read each other's levels and quality of participation. There should be stated commitments from everyone on the team to be actively present in the given project, and define what that means in terms of specific actions and behaviours.

2.3 Vicente's Cognitive Work Analysis[3]

The Cognitive Work Analysis (CWA) is a powerful tool that can be used to establish structure to a given workspace. The CWA provides guidelines for the identification of essential elements in the workspace. If done properly, it will give you a thorough representation of the system that you want to describe. This methodology will be used to map the Bridge project and pin down relevant components in the model. It will also be used as a compliment to the simulation part of the report, displaying model elements that are too complex to simulate.

Vicente's CWA is divided into five different phases, where the first phase is an analysis of the *work domain*. This step is the most basic one, and is carried out to represent the system in question on an ecological (physical) level. Vicente argues that the ecological point of view is central when conducting a CWA, because the physical environment (it could be an apparatus, a space, physical laws and so on) has its wide range of restrictions that in its turn lays the foundation for how the operation will look "on top" of the work domain. An analysis of the work domain shall work as a map that shows the environment in which actors (e.g. traffic controllers on an airport) has the possibility to act.

The second phase of the CWA is the *control task analysis*, which adds further to the environment previously built up in the work domain. In this step you map *what* shall occur in the work domain, where certain constraints are made up to verify a final product (but the constraints could also be about results and so on). This constraint based analysis lays, as previously mentioned, its focus on *what* shall be done, regardless of who's doing it or how it's done. Control tasks could be illustrated as travel directions on the map that has been built up in the work domain. The second phase also lies on an ecological level and inherits the set of constraints that have been stated in the work domain. Control tasks can only act within the borders (a certain type of equipment, the laws of gravity etc.) that are given in the work domain. With this step the degrees of freedom and the liberties of action decrease since a control task usually only uses a part of the work domain.

The third phase of the CWA is the *strategies analysis* which answers to the question *how* the control tasks can be performed. Different strategies represent different processes and are not dependent on who's doing them. A strategy inherits the current constraints built up by the work domain and the ones that are built up by the analysis of the control task. One control task can often be performed by a range of different strategies. The choice of strategy depends on what context it is in, i.e. increasing workload could lead to a change from one strategy to another.

The fourth phase of the CWA is the *social organization and cooperation analysis*. In this phase a representation is made of how work and fields of responsibilities are distributed to the different actors in the system. Here is decided *who* shall be assigned to different places in the work domain, *who* will perform what (the control tasks) and *who* will perform which tasks. Furthermore, in this phase you map the groupings of actors and how the communication between actors and groupings looks like in the system. Also, this analysis should identify decision orders for different parts of the system (i.e. authoritarian levels).

[3] Cognitive Work Analysis, Vicente, p. 149-275

The fifth and final phase of the CWA is the *worker competencies analysis*, and its task is to map the different actor's skills (that is, identify which constraints that the human actors should have). Besides the actors basic human attributes (e.g. cognitive attributes, as limitations in the working storage), this phase analyses domain-specific features (i.e. surgeons knowledge about the human anatomy).

On a more general level, the five steps of the analysis can be divided into two parts. The first three phases constitute the demands, which the system is meant to satisfy. The last two phases of the analysis then describe what actors and what form of organization that are suitable in order for these demands to be satisfied. Each phase that is included in the model, inherits the attributes that have been embedded in the previous phases.

The five stages of the CWA are illustrated in figure 1 on the next page.

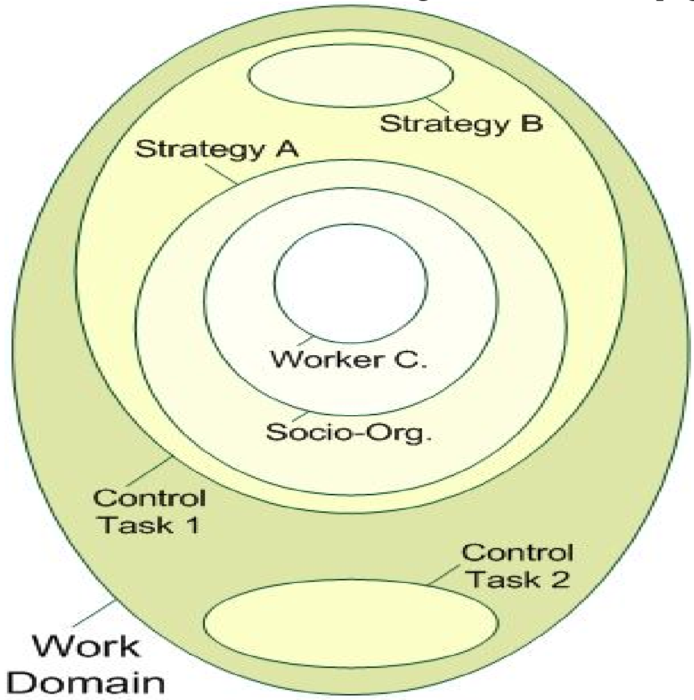

Figure 1: The five stages of the CWA framework[4].

As mentioned previously, the five steps of the analysis embark on an ecological level. This means that the analysis should be driven by an explicit investigation of the constraints that the physical environment imposes on action. However, as the CWA evolves, the constraints that are set up in each phase deploy towards a cognitive level. Vicente argues that it is important, on an early stage, to establish constraints that are compatible with the environments of the system. This will later on lead to the optimal cognitive constraints for the actors, who are operating in the system. The final aim for the analysis chain is to minimize the cognitive load for the actors, so that the working tasks should be as easily performed as possible. As you go further in the analysis chain, the degrees of freedom for action decrease for the actors.

There is a one-way dependence between the phases of the analysis. If anything should be modified at the first stage (the work domain), this will necessarily lead to modifications at the upper levels of the analysis. The control tasks then have to be

---

[4] The Cognitive Engineering Laboratory

changed and adapted to the new set of environment. As a consequence the strategies will change accordingly, and so on.
Vicente’s ecological approach constitutes a break towards the traditional cognitive perspective, which only acknowledges the relevance of cognitive properties in a system. According to Vicente, a proper analysis must implement environmental constraints in order for the cognitive constraints to be meaningful. This aspect makes his way of performing the work analysis a *formative* one. A formative analysis can be seen as a model that formulates demands, and these demands have to be satisfied in order for the system to *be able* to work in a certain (desired) way. In this aspect Vicente’s CWA differs from other models. Examples of such models are the *normative* analysis and the *descriptive* analysis (both which are criticized by Vicente because they lack in preparation for unforeseen incidents and have a weak connection to a system’s environmental demands). The normative analysis bases its foundation on how actors *should* behave in a system, while the descriptive analysis simply describes how the actors *actually behave*.

Chapter 3

Mapping of the Bridge organization

3.1 Introduction to Bridge[5]

The idea behind designing the Bridge-model was to create an organisation that greatly enhances the force of innovation in Europe (with focus on the area of nanomedicine). There are already a large number of initiatives in Europe that promote and support research and innovations in different ways. The Bridge model was developed to complement rather than replace or compete with these existing structures. The main aim of Bridge is to successfully and efficiently combine the three cornerstones of what is known as the *knowledge triangle* - Education, Research and Innovation (illustrated in figure 2) - to create a European innovation-powerhouse. It takes advantage of the best academic research and education and combines it with leading technological industries to form a strong market and society driven research agenda. The Bridge model will thus provide a robust infrastructure to systematically and successfully promote academia and industry research collaborations.

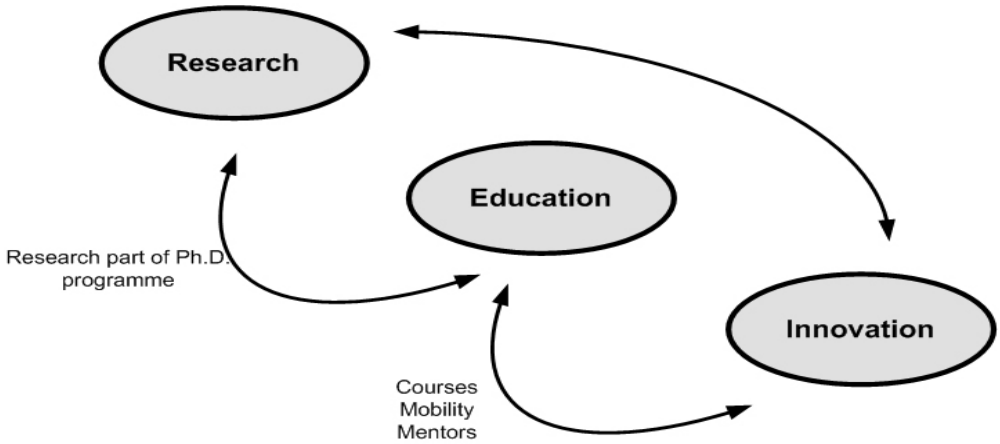

Figure 2: The three cornerstones of the "knowledge triangle"[6]

Bridge is designed as virtual research institute with its active members (academic researchers and research companies) spread throughout Europe but with a strong and purposeful organisation as backbone to initiate and manage projects and to drive innovations.

3.2 The Bridge Organization[7]

The Bridge organization consists of three main bodies and five sub bodies. The three main bodies are the Bridge board, the Bridge scientific council and the Bridge

---

[5] Bridge model, The Bridge Organization, p. 8-11

[6] Ibid, p. 10

[7] Ibid, p. 11-12

executive office. These three bodies make out the backbone of Bridge as well as being the governing body of the organization. As shown in figure 3 on the next page, the Bridge executive office consists of several sub bodies called coordination units. These units are the KLO coordinator, tech transfer unit, research project unit, administrative unit and the educational programme unit.

The main actors in Bridge are the members (pink oval in figure 3) that consist of the leading academic researchers in the field of nanomedicine as well as various research companies that can both directly benefit and contribute to joint research collaborations. The company members are also an important funding component in the model.

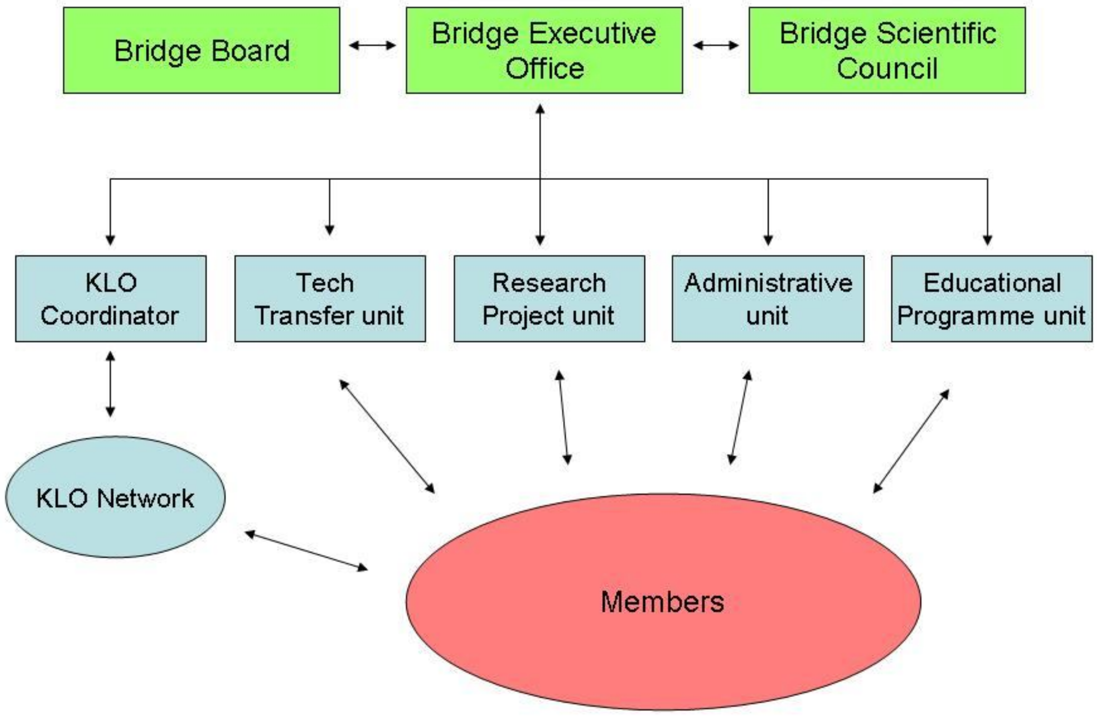

Figure 3: The Bridge organization and members. The arrows in the figure illustrate the information flow between the different bodies, and also the hierarchical structure of the organization[8]

3.2.1 The Bridge Board[9]

The **board** will include members who have an extensive experience in their respective areas of expertise. These members would originate from successful careers, and will be given the task of directing the strategic activities of Bridge. The board is responsible for the planning of all operations within Bridge, and they have the final word on every matter within the organization. Its' members should preferably be

[8] The Structure of Bridge, adapted from the Bridge model

[9] Bridge model, The Bridge Organization, p. 25

former CEO’s or distinguished professors, performing the following up of Bridge’s activities and having the ultimate decision power for the organisation’s endeavours.
The board members will be nominated and selected by the Bridge members, together with the Bridge council and the KLO network. Every member is selected for a term of four years, and the maximum total length for a board member is eight years. Two members will be replaced (or reselected) every year, which means that the Board will consist of a total of eight members.

3.2.2 The Scientific Council[10]

The **scientific council** will include researchers from both academia and industry. Their job is to make recommendations concerning the different activities that evolve in Bridge, and will therefore function as an advisory board. Their recommendations are passed on to the Bridge board, and then the board will make the final decision on the subject. There are three major areas within the Bridge organization that the scientific council will have their focus on, and that’s giving recommendations regarding research projects, technology transfer and the educational program. The members of the scientific council will not be employed by Bridge, but all their costs will be covered.

3.2.3 The Executive Office[11]

The executive office is headed by the managing director of Bridge. The director is responsible for all the ongoing operational and communication activities, therefore the executive office can be seen as the Bridge organization’s “control room”. The executive office is divided into five different coordination units. For every unit there will be a coordinator that will head the unit in question, and the coordinators will have a number of assistants to help him/her run the unit. The number of assistants will vary with the workload for each sub unit.
To get some more insight in what the different units function is, we will now go through each one of them starting with the so called *knowledge liaison officer coordinator* and the *knowledge liaison officers* (KLO’s).

3.2.4 Knowledge Liaison Officers (KLO’s)[12]

The KLO’s will constitute a network with a crucial role to the Bridge organisation. Members of the KLO network are responsible for identifying and assembling the most promising researchers, the most innovative ideas and the most interesting companies throughout of Europe. In other words, the KLO’s will perform the actual matchmaking between potential members of Bridge.

This responsibility demands that the KLO’s have great insight and knowledge on what is going on in the region that he or she represents. They should keep an interactive contact with companies and researchers in the region on a regular basis. The KLO’s will be highly aware of Bridge’s possibilities of funding, and at the same time know about specific industrial needs formulated in Europe. Since there is a representative from the European Commission in the Bridge scientific council, the

[10] Ibid, p. 28-29

[11] Ibid, p. 25-28

[12] Interview with Beatus, Paul

KLO will be given first hand information on scientific needs and focuses defined by the Commission.

The KLO network will meet face-to-face three times per year, and in addition to this they will engage in monthly internet conferences. The KLO's will report continuously to the Bridge Executive Office and to Bridge members of interest. These reports will have the purpose of supporting innovation within the Bridge organisation, by giving updates on current needs, ideas, facilities, publications and projects. The information in the reports will also be added to the Bridge web-tools platform. This web-tools platform should be checked on a regular basis by the KLO's in order to maintain a good view of present activities within Bridge.

The KLO will have a PhD and at least five years of experience from technology transfer or industry. He or she will also be experienced in the academic sphere.

3.2.5 KLO Coordinator[13]

The KLO coordinator will work closely with the other coordination units, to see to that the cooperation between the KLO's and coordination units run as smooth as possible. Every year the KLO coordinator performs evaluations on the KLO's, looking at such parameters as number of new memberships and number of new patent applications generated by the KLO's.

3.2.6 Technology Transfer unit and its strategy[14]

Technology transfer is the process where scientific research findings are translated into practical applications. High quality technology transfer is crucial for successful innovation and it is the aim of Bridge to put great efforts to provide superior technology transfer services. The Bridge strategy is to combine an efficient in-house technology evaluation system to maximise idea evaluation and then to partner with the best existing technology transfer offices in Europe to drive the commercialisation process. The technology transfer evaluation function will monitor the progress of different projects in the Bridge organisation. The research teams working on each project will continuously report to the research project unit and the technology transfer unit. These reports will ensure that deadlines are being kept according to initial agreements, and will also constitute a continuous information flow containing new developments and research findings.

When a new research finding is presented to the technology transfer unit, it will be crosschecked with several databases to examine its potential. The research findings are matched with a so-called "problem bank" (an online database set up by the Bridge organization, where member companies and academic researchers can add problems and missing links in their research chains), patent databases to check their feasibility, potential target markets, and suitable "go-to-market strategies". After crosschecking a research finding, the technology transfer unit will place it into one of three categories: 1) obvious commercial value, 2) for further investigation, and 3) no obvious commercial potential. Those with an obvious commercial value will be assigned to a selected technology transfer office. Research findings that deserve further investigation will be presented to teams of Bridge PhD students as "real project" assignments during courses in the educational programme.

---

[13] Ibid, p. 27

[14] Bridge model, The Bridge Organization, p. 86-90

3.2.6.1 Assigning technology transfers offices (TTO's)[15]

It is very common for universities today to have a technology transfer office. These branches of the universities help to formulate research output into commercial products. Most of the researchers that contact TTO's are local, and belong to the university where the TTO is situated. However, many TTO's are also open to external contributions and are likely to process such research findings in exchange for a commission or equity.

There are several hundred TTO's throughout of Europe. They share the same fundamental purpose described above, but can also differ on how they work towards this purpose. Some TTO's are very prominent on acquiring projects and evaluating them, others have competent staff and management support that can assist in new start-up companies. There are also TTO's who specialize in the signing and negotiating of license agreements and patent seeking.

One of the goals for the Bridge organisation is to partner with some of the highest ranked TTO's in Europe. The selection process will base its search for top TTO's on their excellence, business focus and geographic location. When a TTO is considered to have the desired qualities, an invitation will be sent offering the TTO to become certified for the Bridge organisation. The main goal for TTO's within Bridge will then be to maximise the development of intellectual property (IP) generated in Bridge research projects.

Mainly, there are two ways of generating money from intellectual property; by licensing fees or equity positions in start-up companies. When choosing the first named option, Bridge would acquire an up front licensing fee for the given IP and further royalties on future sales. If the second named option is used, Bridge would acquire an equity position in the start-up generated from the given IP. A start-up is a company that is created for the IP and Bridge would obtain a certain amount of ownership by shareholding a proportion of the start-up. For further reading, Michael J. Bray and James N. Lee discuss the cons and pros of this matter in their paper "University revenues from technology transfer: licensing fees vs. equity fees"[16].

3.2.7 Research Project unit[17]

The research project unit manages all the research projects in the organization. Its main task is to assign suited project managers for each project. A project manager is a person that guides and coaches the research project teams, and he/she will handle about four to five projects at a time. The research project unit is also involved in the preparation of new projects, helping with agreements and project plans. Furthermore, this unit also reports back to the universities and companies that are involved in the projects.

---

[15] Ibid, p. 86-91

[16] Bray & Lee

[17] Bridge model, The Bridge organization, p. 25-27

3.2.8 Administrative unit[18]

The administrative unit does not need a long presentation, it simply administrates all the ongoing activities within Bridge (i.e. keeping track of all the members and their agreements). It also keeps track of the Bridge budget, and makes sure that everyone in the organization follows it. Also, the administrative unit runs all the correspondence with the outer world.

3.2.9 Bridge educational program[19]

One key aspect of Bridge is to fully integrate education with research and innovation. Bridge will have an educational programme for promising PhD student. This program will be in parallel with the student's regular PhD studies, and will last for the whole full three years of a students PhD programme. The overall aim of the Bridge educational programme is to create a pool of PhDs with a strong sense for the commercialisation process. The PhD student will able to take advantage of different components of the Bridge educational programme (taken from Bridge collaboration model, P. Beatus personal communication):

- Research work within a Bridge project at an elite laboratory
- A Bridge course programme, including summer and winter courses, with top lecturers in nanomedicine and entrepreneurship, in addition to the course curriculum of the home university
- A mentorship programme, with mentors from industry or with vast entrepreneurial experiences, who will guide the student into translational research and commercialisation
- Mobility grants, to enhance mobility among students to a different country than the home university, either by:
    - internships in industry (in order to provide the student with industry experience)
    - placement in an academic group, preferably within a different discipline than the present one (to enhance the interdisciplinary background).

Apart from the academic orientation of the programme, the focus will lay on learning the student entrepreneurial skills. The idea is to equip the students with necessary tools and mindset to be able to seize commercial opportunities in their own research in the future.

The students will have the benefit of having a mentor via Bridge through half of the educational programme. All the mentors will come from the industrial world, giving the student an insight in industrial research and development.

[18] Interview with Beatus, Paul

[19] Bridge model, The Bridge Organization, p. 92-100

3.3 Members of Bridge[20]

The members of the Bridge organization will origin from all parts over Europe. They will have different backgrounds and have different competencies. Roughly, they are divided into two major categories, academic and industrial members. An industrial member can be a single person, but it doesn't have to be. It could be a small to medium sized enterprise (SME) or even a large multinational company. What they all have in common is that their companies are active in product development rather than basic research. The academic members will typically be individual principal investigators (PIs) with their own research groups. It is important to emphasise that it is the PIs that are members, not necessarily the universities as a whole.

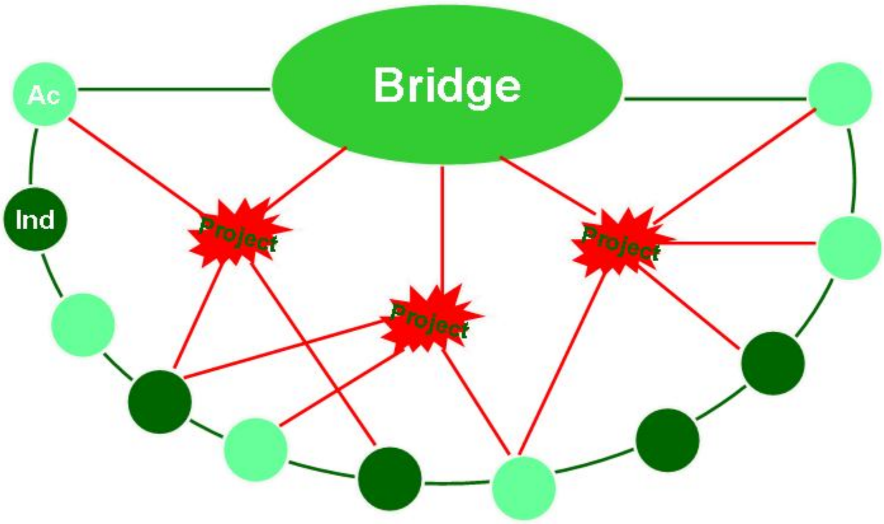

Figure 4: An example of how the Bridge organization and its members could look like. It displays how academic and industry members interact when research projects are formed[21].

To become a member of the Bridge organisation, there is a certain criteria to be fulfilled. The researchers need to have high scientific credibility, but also be "hungry" for breaking new ground and keen to collaborate with people in different fields. Another criteria is that universities, SME's and large multinational companies need to be based in Europe.

All members, academic or industrial, have the option to be a full member or an associate member. Both of the memberships are limited in time for usually three years, and with a 90-days cancellation notice.

Being a full member means that you are committed to actively engage in Bridge projects, but also access to all features and services that Bridge provide and that you have the right to nominee members to the Scientific Council and the Bridge Board. Industry members will be charged an annual fee.

If you're not an active member of Bridge, then you are an associate member. Being an associate member means that you get regular updates about what's happening within the Bridge organisation through newsletters and seminars. You can also take advantage of some services that are provided by Bridge. By being an associate

[20] Ibid, p. 57-60

[21] Ibid, p. 57

member you are not required to pay any annual fees, though you have to pay for the services of your likings. An example of an associate member could be a university.

3.3.1 The main tools of communication in Bridge[22]

The key to success for the Bridge model as an organisation lies in its ability to communicate effectively with its members. In the model a number of communication tools and strategies have been developed.

Bridge interacts with its members at several different levels. The main aim with the communication structure in Bridge is to promote and initiate research collaborations that will result in innovations. The most important communication feature is the KLO. The KLO directly interacts with companies (SME's, large companies and multinational companies) and researchers. The interaction with researchers is rather straightforward, the KLO and the researcher keep in touch on a regular basis. With SME’s, the KLO represents the first point of contact and the natural interface to reach academic researchers. The KLO also ensures that the interactions between researchers, company and university take place at the appropriate level. For large multinational companies the role of the KLO becomes even more important as a first point of entry into European academia, since the headquarters of these companies will often be located outside Europe.

3.3.2 The strategic innovation agenda[23]

Bridge will have a Strategic Innovation Agenda (SIA) that will be redefined every year. Scientist within Bridge will review the SIA annually and recommend some possible changes to be made. The scientific council and the board will then revise the changes, and finally approve the SIA. The SIA will contain specific long term or short term goals and visions. An example of a long term goal could be the creation of a synthetic kidney, whereas an example of short term goals could be the various subprojects required to build a synthetic kidney.

If a project’s progression does not meet Bridge’s expectations or goals, Bridge may modify the management of the project. If the modifications do not give satisfying outcome, Bridge may choose to terminate the project. A project’s duration is estimated to be on average between two to seven years

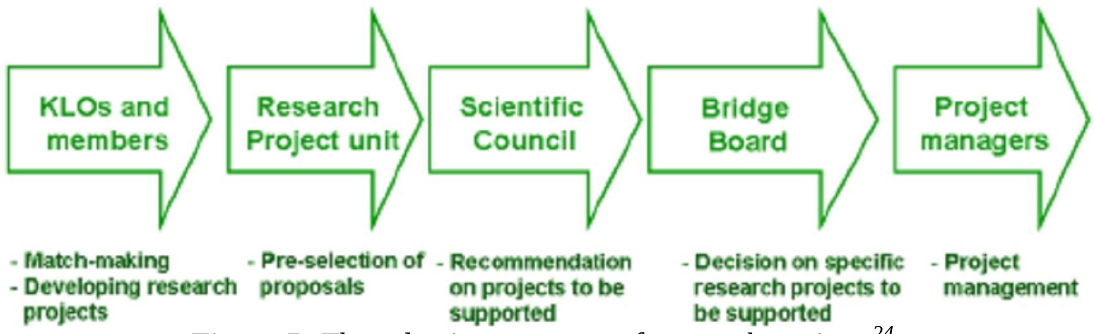

Figure 5: The selection progress of research projects[24].

[22] Ibid, p. 65

[23] Ibid, p. 68-75

[24] Ibid, p. 70

When a SIA is finalised, Bridge members can jointly submit applications for how to solve the proposed SIA goals. The proposals will consist of a short description of the team and the project that they are applying for, and how they will achieve the projects goals. The main issue here is to avoid extensive, bureaucratic and time consuming applications and promote formation of viable teams that constructively collaborate rather than just being a team on paper for the sake of getting funding. The KLOs will play a crucial role to communicate the SIA goals to the members and in bringing team members together through match-making. The proposals then have to get the approval of the research unit and the scientific council, who then forwards the best proposals to the Bridge board to makes decisions and final approvals of which proposals that will be supported.

Chapter 4

Bridge from a theory perspective

One of the aims of this master thesis is to evaluate the proposed Bridge model in the light of previous research on virtual organisations and networks to understand whether it fulfils some of the key criteria for success.

4.1 Bridge compared to "Guidelines for virtual organizations"

In this chapter we will compare Bridge to the criteria for virtual organisations from the VOSTER project. According to the VOSTER project, there are a number of different key positions in a network and a virtual organization. Since a lot of weight is put on these positions, we will compare them with the Bridge organizations structure and layout.

4.1.1 The Network

We will start out with comparing the key positions in a network according to VOSTER with the organisational layout of Bridge. According to VOSTER, virtual organisations are temporary entities springing from a larger network. In Bridge, the virtual organisations correspond to temporary research projects that are formed by Bridge members. The Bridge organisation with its members thus correspond to the network described in VOSTER.

4.1.1.1 Broker

A broker is supposed to bring in new business opportunities and new customers to the network. The Bridge organization does not have a position that fully matches the description of a broker; they rather have two positions that cover the broker's tasks.

The scientific council is the source of new business opportunities in the Bridge organization since the council decides which fileds Bridge research will focus on. In this sense Bridge makes its own business opportunities through the scientific council.

The second part of the broker's task, bringing new customers to the network, is mainly carried out by the KLO. The KLO has a wide range of tasks, and one of them is to have great insight and knowledge on the industrial and academic activities in their given region. Thus the KLO will have knowledge about which possible new customers that exist and will make contact with these.

4.1.1.2 Manager In-/Outsourcing

A Manager In-/Outsourcing shall act as an interface between the network and the participating companies of the network. This role fits well in with the general description of a KLO since the major role of a KLO is to act as an interface between the Bridge organization and its members. Furthermore, the KLO will also play an active role in forming research teams and this is also one of the manager in-/outsourcing tasks. In conclusion, the KLO fulfils the criteria of a manager in-/outsourcing in the Bridge network.

4.1.1.3 Network Coach

A network coach is not related to a specific company or business opportunity, and the main purpose of the network coach is to maintain a functional co-operative network culture. Thus the Network coach can be considered to be the administrative backbone of the network. This feature can be compared to the Bridge executive office with its five units. Every unit has its own coordinator and varying number of assistants. The purpose of the units differs from unit to unit, but the main purpose of all the them is to help the Bridge organisation to run smoothly and to maintain a functional network. Thus the main difference between the guidelines from VOSTER and how the Bridge organization is structured lies in that there are several network coaches instead of just one as in VOSTER.

4.1.1.4 Auditor

The auditor ensures the financial stability in the network and has the financial control of all ongoing operations. In the Bridge organization, there is an admin unit that is responsible for the Bridge budget. They make sure that the budget is followed by all members and keep track of all the expenses. Although the admin unit is responsible for the budget, it is the managing director that is responsible for all the ongoing operations. So the admin unit, together with the managing director, fulfils the tasks of the auditor.

4.1.1.5 Leadership team

According to the VOSTER consortium, the leadership team is supposed to be represented by the CEO's of the network companies, which in Bridge would correspond to the CEO's of the network industry members. However, this is not the case in Bridge. The leadership team in Bridge is divided between the scientific council and the Bridge board. The leadership team is supposed to generate the network strategy and its alignment. In Bridge, the scientific council prepares a SIA which is presented to the Bridge board which then approves the SIA. To conclude, the Bridge board together with the scientific council represents the leadership team proposed by VOSTER.

4.1.1.6 Business model

Besides having a certain set of positions in the network, the VOSTER consortium also points out that it is important to have a business model for every business opportunity that arises. This is also done by Bridge, when the Strategic Research Agenda is finalised, scientists of the Bridge organisation send in proposals of how they aim to solve a specific research problem. Part of the application briefly describes the business model. The proposals consist of a description of how to solve the research problem, how much money they will need and which the team members will be in the team. If the proposal is approved by the Bridge board a research team is created. In the Bridge, the research teams can be considered as small virtual organizations.

4.1.2 The Virtual Organization

In the next section, a comparison is made between Bridge and the guidelines from VOSTER concerning virtual organizations.

4.1.2.1 Business architect / Competence manager

According to VOSTER, the Business architect/Competence manager is responsible for developing the business model and bringing the involved partners together. In Bridge, the business model corresponds to the research plan which is prepared by the researchers in the research team together with all the involved partners in the project. As mentioned previously, the KLO helps in bringing the partners together.

4.1.2.2 Project team

The Project team is a rather straight forward position that every virtual organization must have since it is the core of the virtual organization. Bridge has their research projects that correspond to VOSTER's definition of a project team. From VOSTER's research, they point out that it is important to have ground rules and coaching of the team. The research projects in Bridge will have clearly defined ground rules that are stated in written contracts between each member and Bridge. Furthermore, the business model will also contain certain ground rules that will state the budget, time frame and so on. The KLO, together with the project managers, will coach the research project members and provide guidance to make the research process as effective as possible.

4.1.2.3 Project Manager

In Bridge, every research team will have a project manager who is in charge of the research project. Every project manager will have about four to five projects to coach at the same time. The VOSTER report points out several other important tasks to the project manager. These tasks include to help planning the budget and organizing resources in the research projects. All of these tasks are handled by Bridge's research project unit and its project managers.

4.1.3 Start up phase

The VOSTER project also points out aspects that are important when Bridge enters its start up phase. For example, the report states that it is important to have a clear vision and aim to identify the overall purpose of the organization. Bridge vision is to form an organization that stimulates the force of innovation in Europe, in particular in the area of nanomedicine. This vision, or purpose, is clearly stated throughout their organization.

Bridge already has a good understanding and definition of what markets they want to address. Their field of expertise lies within the field of nanomedicine, and consequently their markets are within this field. The products that stem from Bridge research will already have been checked so that a need and a market is present when the product is ready to be commercialized. Furthermore, the competencies of the Bridge members and the people in the Bridge organization are well defined. All of these factors are in line with the recommendations from the VOSTER project.

All together, Bridge may not be a replica of the VOSTER structure. But Bridge fulfils all of the positions and goals above by combining their own positions. So every function that VOSTER points out to be important is included in Bridge. That gives Bridge a secure and working foundation to build its organization on, and also gives Bridge all the qualifications to build a successful network that generates successful VO's.

4.2 Bridge according to the framework of CWA and Leading virtual teams that learn

In this chapter the five steps of the CWA method will be applied to map the Bridge organization. This will be done in combination with the framework of Kimball and Digenti's report "Leading virtual teams that learn". The two methods fit well together when identifying relevant aspects of Bridge. The CWA model maps traditional work place characteristics and "Leading virtual teams that learn" maps Bridge's characteristics as a network with virtual organizations. This chapter will work as a complement to the simulation, with the purpose of identifying model components that are hard to operationalize but yet important for Bridge's results.

4.2.1 The work domain

It is difficult to map the Bridge work domain with conventional restrictions. Since the Bridge project will include members situated in different parts of Europe, the constraints on the work domain could stretch as far as to the outer boundaries of Europe's geography. This puts Bridge as a system on a macro ecological level.

The vast extent of the Bridge work domain has several implications. For example, it will generate limitations on the frequency of face-to-face contact between members in the Bridge network. It makes the network a virtual one, and this issue will have to be addressed in order to make the network efficient and sustainable. The virtual nature of the Bridge network puts constraints on the actions performed within the organization. However, rather than being conventional constraints, the limitations are constituted by the openness of the network. The restrictions of the virtual network create a foundation that is inherited by the control tasks.

4.2.2 The control tasks

The control tasks tell us *what* shall be done within the Bridge work domain. There are a large number of control tasks taking place in the organization that could be addressed in this section. We will list some of the essential ones below.

On a large scale, the actions within the virtual network will be research-related and stimulate the production of new innovations. This is the overall goal with Bridge and should be reflected by the control tasks. To achieve this goal, however, the operations need to be performed within the borders that were given by the work domain.

The actors must take into consideration that virtual networks require certain working methods, in order for them to be successful. For example, it is important that there is a mutual trust between members in the Bridge network. This is essential for the Bridge research teams to function, since the team members will lack opportunities to interact face-to-face. A way to ensure this trust is to insert sub tasks or achievable milestones during the research projects within the organization. Coming through with these milestones will make a fellow member, although situated in a far distance, trustworthy and reliable for future tasks.

Bridge must also make sure that the role for each member is clear and well defined. A researcher has to know explicitly what he or she is expected to accomplish by the Bridge organization. This will help minimize misunderstandings within the research team, which often happen in unfamiliar dynamics in virtual networks.

It is also important for the Bridge organization to ensure that research members accountable to their commitments in the project. Research projects that take place within the organization are supposed to generate new innovations and correspond to current market needs. With this is mind, there must be control tasks implemented that will guarantee the keeping of deadlines, working accordingly to the market needs etc.

The KLO will not necessarily be limited by the constraints that were put up by the work domain. They will be regionally based and therefore have a geographically closer connection with Bridge members in their region. Nevertheless they are a part of Bridge, and the outer boundaries of the KLO work domain will be the same as for the Bridge work domain. Also, the members within the KLO network will be in a continuous dialogue with each other. They will engage in monthly Internet conferences, and hence the KLO network is of virtual nature. This will stimulate the need for the same type of control tasks that are given for the research teams. On the whole however, KLO control tasks will help ensure the force of innovation within the Bridge network. The KLO's will assemble members that are suitable for given projects; a recruiting process that derives from the KLOs' knowledge on current industrial needs in Europe.

There must also be control tasks of the regulatory kind. In order for Bridge to have an efficient system, it has to include units that have final executive power (the executive office and the board).

Finally there will be control tasks that transform research findings within Bridge to actual innovations. This task is represented by the technology transfer unit in Bridge and this control task will help generate commercialized products, which eventually leads to increased revenues and thus further stimulate research in Bridge.

4.2.3 The strategies

There are numerous *strategies* that can be applied to each control task described above. A strategy answers the question *how* a control task should be performed, and the answer will vary depending on the workload, changing demands, information accessibility etc.

We mentioned in the previous sections that it is imminent to make the virtual networks within Bridge sustainable. A way to strengthen the Bridge networks is to choose the proper media with which the members communicate. Different situations might require different forms of communication, and in order to ensure sustainability, Bridge should adapt its repertoire of communication tools accordingly. Furthermore, Bridge should establish a practise for the frequency of communicating. For example, lack of response from certain team members, might cause the remaining members to lose trust in the team performance as a whole. Therefore, there must be established procedures for response norms, for the whole repertoire of chosen media.

It is also important for Bridge to have a good web platform. This will make it easier for members to stay "in the loop" of activities within the organization. The choice of web tools could also be combined with the issue of "making the whole visible". As we mentioned in the theory on virtual teams, it helps tremendously if there is some sort of graphical representation of the research team you are in. This is addressed by Bridge using the "Second Life" platform. The programme enables its users to interact in a three dimensional world with the possibility of holding lectures, seminaries etc. Members of a Bridge virtual network can attend such events, and keep discussions on given topics in real time. Since they interact in a mutual interface, it provides the members with a feeling of belonging to a physical unit. This will enforce team building, and it will also be obvious who is contributing with what at meetings.

As mentioned in the control task section, it is important that everyone in Bridge knows his or her role and what he or she is expected to accomplish. In order to ensure this, and to secure the maintenance of deadlines, Bridge should provide documents with explicit points that have to be addressed by the researchers. These documents could be provided by the administrative unit, and must be signed by each researcher that wishes to be a member of Bridge. The information in the documents needs to be clear on definitions; what it means to be an active participant, to keep deadlines, what specific actions he or she is expected to perform etc.

The units that have the executive power need to have a clear, overall view of the system. In order to ensure this, and to be able to make reinforced final decisions, the units need to keep a close and active communication with actors on levels below in the organization. It is important that they are constantly updated and have first hand information on what is going on in the system. As for all the Bridge members, the executive unit need to be "in the loop" for the decision making to gain the organization as a whole.

Regarding strategies for the control tasks that will generate commercialized products, Bridge will consider the market potential for the research proposals and also evaluate the commercial potential of all of the research findings. This will ensure higher innovation value and increase the probability for successful commercialisation.

4.2.4 Social organization and cooperation

The fourth part of this chapter will map the distribution of responsibilities within the Bridge organization. It will describe *who* is meant to perform which control task, and how this actor can do it. In this section we will also do a representation of how the communication between actors looks like within the organization.

First there are the KLO's, who give advice for assigning new members to the Bridge network. The professional role of the KLO will make sure that the members have competencies that are relevant to given projects. A part of the KLO job description is to stay updated on industrial needs in Europe, and he or she will get first hand information about this from relevant interest groups.

Second, we have the members, who will be parts of different research projects. The members will derive from either the academic sphere or the industrial sphere. These actors will be responsible for performing the actual research within Bridge.

Members could be situated anywhere in Europe. Different researchers that belong to the same research team might be hundreds of miles apart, which put a lot of responsibility on the team's project manager and the KLO to create the feeling of unity.

The project manager is responsible for several research teams. Bridge estimate that one project manager could effectively handle 4-5 teams. This actor is responsible for giving sustainability to the virtual team that is formed around a research project. He or she would be providing team members with the type of subtasks described above, making sure that these targets are on a suitable difficulty level. The project manager would also be responsible for informing about the norms for response, regarding communication in the virtual team. Overall, the project manager could be viewed as the rail of the research teams which keeps the team on track. Another task that the project manager should fulfil together with the KLO is to make sure that the roles in each research team are clear and well defined. It is important that each member knows exactly what he or she is expected to accomplish in the project to maintain the trust avoid misunderstandings.

There are two bodies in the Bridge organization that function as the main decision makers. First we have the board, which has the final executive saying in major issues regarding Bridge. In parallel is the scientific council, working as an advisory unit and hence is the provider of the organization's strategies. In between these two bodies is the executive office; a unit that executes the decisions made by the board. Within the executive unit is the administrative unit, which is responsible for all the administration within Bridge including agreements, budgets maintaining databases of all members and public relations.

Finally, the technology transfer unit is responsible for evaluating research findings that are generated in Bridge projects. Those research findings that have an obvious commercial potential will be assigned to a selected technology transfer office which will manage the commercialisation process for that project.

So far, this section has described *who* is supposed to do *what* in Bridge. But it is also important to highlight significant flows of communication between the different bodies. The members of the research teams must keep a tight communication with the project manager. This will help the members to gain line of sight and to stay in the loop of the project's progress. It will also give the members feedback and let them know if a different course of direction in their research is appropriate. For the project manager's part, this tight communication will let him or her know the status of the research and when it is time to forward the research results to the technology transfer unit.

The KLO's must keep an active contact with companies and researchers in the region he or she represents. This, combined with the KLO's insight on industrial and scientific needs, will ensure that the right people are being gathered for given projects. For this to work, the KLO must also keep a continuous communication flow with the KLO coordinator.

The executive office must keep close contact with the board and the scientific council. Since this unit executes all the major decisions, it is important that information from the board and the council is forwarded without any misunderstandings. The units of the executive office (especially the technology transfer unit) also have to maintain an active contact with each other and all project managers. This way the technology transfer unit is able to monitor the progress of all the projects within Bridge, and pick up research findings with high potential commercial value.

4.2.5 The worker competencies

The last section of the CWA analysis concerns the mapping of the skills of different actors in Bridge. The organization has sufficient competencies on all levels of the organization, many of these described in chapter 3. An example of such a competence is that of the KLO. A KLO will have a PhD in his or her discipline, with at least 5 years of experience from technology transfer or industry. He or she will also have both the social and the technical skills required to interact with academics and industry representatives, and to establish mutual trust with these actors. It is essential that the KLO will be experienced in both the academic and the industrial sphere. He or she must be able to recognize innovation skills in both subject areas.

There is an extensive amount of actor competencies that are needed by Bridge and they are simply too many to address in this section. However, Bridge has developed thorough profiles for every actor that will be a part of the organization. On the whole, a common denominator for most of these actors is that they should have a PhD with experience from both the industrial and academic sphere.

This part of the report has provided a mapping of Bridge's organization with the CWA framework. The points that have been highlighted constitute important parts of Bridge as a network with virtual organizations. Many of these points however, are extremely hard to operationalize and put actual numbers on. To incorporate all of them in a computer simulation would be incredibly time-consuming and there would be a lack of facts and figures to back them up. Therefore this chapter on Bridge from a CWA-perspective works as a complement to the Bridge simulation. It has shined a light on underlying factors that are left outside of the simulation, but yet will be present when the Bridge model is put to use.

With these underlying factors in minds, the report will now move on to its second part – simulating the Bridge model.

Chapter 5

Simulations

5.1 Background: Modelling theory

So far Bridge has been analysed from a theoretical view point to address whether the Bridge-model fulfils the basic considerations for virtual organisations. The aim of this thesis is to better understand how the different subcomponents in the model interact dynamically and to reveal higher order relationships that are not evident by looking at the components by themselves. The Bridge-model is a system and we have chosen to apply system analysis to develop the tools to build a simplified model (or simulation) of the Bridge-model.

5.1.1 The concept of systems[25]

A system is a collection of components, which together form a unity as a whole. A component itself has certain abilities, and these abilities affect other components in the same system. What actually defines the system is that its components interact and generate system characteristics, which cannot be found in singular components but only in the structure that is formed by the system.

The concept of a system can be applied in all kinds of areas. For example, a bicycle consists of numerous parts that can be separated: the handlebar, the wheels, the chain etc. These items have their own abilities, but when put together they form the bicycle with completely new abilities than those of its separate components.

When giving structure to a system, the first step is to define its purpose. Describing the reality in which the system is placed is often the first step to make this definition. Reality is a vast term that includes both concrete and abstract elements. It is nearly impossible to cover all aspects of a system's reality, and therefore a hierarchical structure must be implemented. This structure will decide on what level of detail the system will be presented, and will also put constraints on the system.

In systems theory, it is common to talk about *pairs of systems*. One of the pairs represents the reality that we want to describe. The other system is a depiction of this reality. A depiction of this kind only contains those components from the reality that we are actually interested in. This depiction is referred to as a model.

5.1.2 The concept of Models[26]

The general definition of a model is that it is *a system that is chosen because it contains essential elements from another system*. Conclusions that are derived from a model should be the same ones generated by the system that we want to depict, even though the model contains less elements.

The modelling process starts with a conceptualisation of the real system, resulting in a mental model. The mental model can subsequently be formalized in an appropriate fashion, for example with a mathematical model or a scale model. If the right

[25] System och Modell – en introduktion till systemanalysen, Gustafsson et al, p. 16-25

[26] Ibid p. 26-32

components are chosen for the model (and irrelevant elements are excluded), the model can be a cheap and safe way of describing a system's reality. Furthermore, there are no external distractions on the model (which would most likely be the case if experiments were performed on the actual system).

There are, however, limitations on what any model is able to do. The model is always a simplification of a given reality, so we cannot be absolutely sure that it includes all the aspects of this reality. Therefore, the model needs to be validated. We need to make sure that the results from the model are applicable for the system.

5.1.3 Classification of models[27]

To be able to construct a model, a fitting conceptual framework is needed. This conceptual framework works as the language with which we are forming our model. Examples of such a language could be the English language, or the language of mathematics.

Some languages that only contain well-defined and univocal concepts are called *formal languages*. The language of mathematics, formal logics and computer languages are examples of this formal type. Models that have been created by a formal language, are consequently called formal models. The main strength with formal models is that you can derive conclusions from them. For example, you can compute a numerical solution with a mathematical model and perform a simulation with a computer model. A dilemma with creating formal models is that you want to do so with a well-defined language but without losing the prime elements of the system you want to describe. This can lead to contradictions, since not all aspects are always translatable into a given language. Therefore it is important to consider such aspects as a complement to the empirical results that, for example, a simulation will show.

5.1.4 Sensitivity[28]

The way components in a system affect the system features is referred to as *sensitivity*. The sensitivity of a system is apparent when a change of value for a certain parameter results in changed system features. For example, if the value of parameter A is changed and this stimulates an even bigger change of another system parameter B, parameter A is said to have a significant sensitivity. In consequence, if parameter A is found to have a significant sensitivity in a model, it is of prime importance that the value of A is thoroughly substantiated and reflects the system as correctly as possible. Thus understanding the sensitivity of the individual components in a system can reveal which key components that require special attention.

The sensitivity can be calculated mathematically by dividing the relative change for parameter A with the relative change for parameter B. If the relative change for A is 10 % and the relative change for B is 2 %, this will give A the sensitivity dA/A / dB/B = 10 / 2 = 5. By giving extra resources to the validation of parameters with significant sensitivity, the model in general will also gain stronger validation.

[27] Ibid p. 33-42

[28] Ibid, p. 78-79

5.2 Translating the model

The following sections will describe how the Bridge model is translated into a numerical simulation. An important first step is to simplify the Bridge model since its large number of variables is too great to include in the simulation. In order to create a simplified simulation without losing the critical elements of the model, there needs to be an identification of model components that are strongly influential on the outcome and the flow in Bridge. Figure 6 below shows a schematic representation of the individual components in the Bridge organization and how they are related.

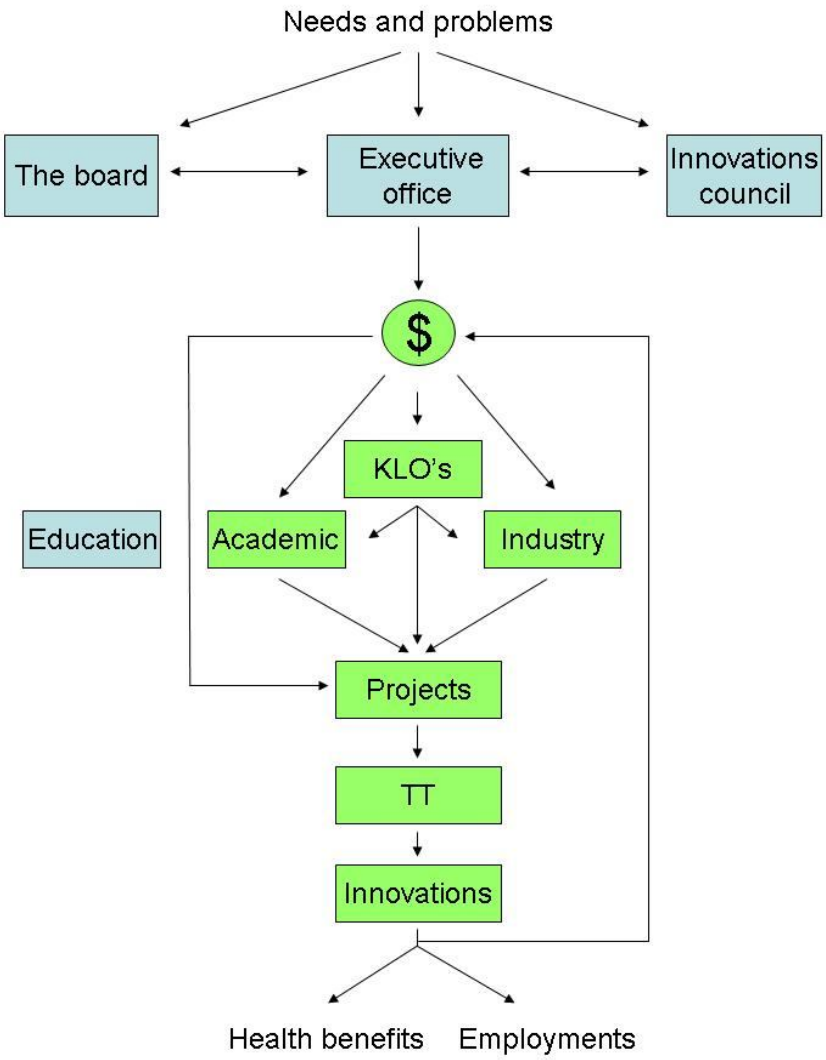

Figure 6: A schematic view of the Bridge organization and the relation of its components.

On the highest hierarchical level are the scientific needs and problems that Bridge research efforts will address. The executive and decision making branches within Bridge (the board, executive office and scientific council) acknowledge these needs and problems, and decide on appropriate research strategies. These components are difficult to translate and validate in a simulation and we have chosen not to include them in this simulation.

The next level represents the components in Bridge directly involved in research activities and project initiation, i.e. the academic and industrial Bridge-members and the KLOs. They engage dynamically in collaborative innovation projects and generate research results which are the basis for innovations. The process of translating research into innovations is mediated through the technology transfer component in the model.

The research projects and subsequent innovations represent the output of Bridge in our simulation. This output can be further translated into society benefits such as health benefits and employment as well as financial outcomes of innovations such as revenues ($).

The aim of Bridge is to generate innovations through research. The top levels of the Bridge organization are difficult to translate and validate in a simulation and we have thus chosen to simulate the core components directly involved in the innovation producing components and how they interact (in green).

Another element in Bridge that we have excluded from our simulation is the Bridge Educational Program. This component's effect on Bridge innovations is also complex and difficult to validate.

5.3 Simulation in Netlogo

The software in which we have chosen to perform our simulations is called Netlogo, a freeware software designed by Uri Wilensky. In Netlogo there is a *system dynamic modelling tool*, which has proven to be suitable for our implementation. This tool uses variables, states and flows to build up a given model (Figure 7).

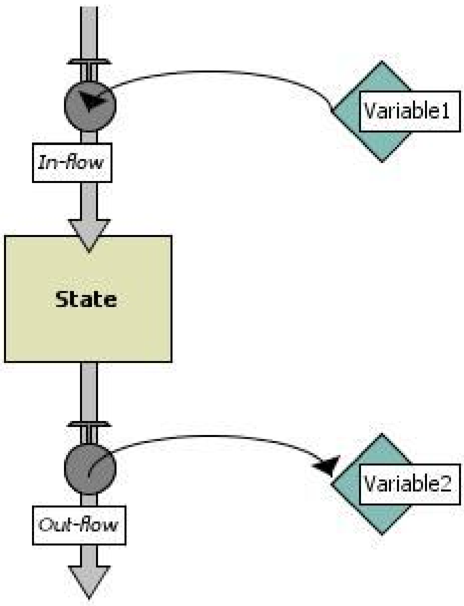

Figure 7: An illustration of simple system in Netlogo. The state is dependant on an in-flow and an out-flow that increases and decreases its value. The in-flow is affected by Variable1 and the out-flow in turn affects Variable2.

Variables in Netlogo are components that can be either constant or changeable. A constant variable does not change over time, i.e. a fixed number. Changeable variables on the other hand can vary over time, i.e. an equation that depends on other variables.

A state is a parameter that starts out with an initial value that is set before the simulation starts. The state can be seen as a quantity value, i.e. a collection of sheep or the amount of snow depth on the ground outside. When the simulation is started, the value of the state can decrease or increase depending on how big the in-flow and out-flow of the state are.

A flow is something that makes the state increase or decrease. It can be seen as a pipe on each end of the state where quantities can come in and out. The flows have regulators which make it possible to control how much you want to come in our out of the state.

The dynamic flow in Bridge that has been illustrated in figure 6 fits well in the Netlogo system dynamic modelling tool. The software provides a simple way to give structure to large dynamic systems and its graphical interface makes it easy to use. The sections below describe how the Bridge organisation is translated into a formal model that can be simulated.

5.4 Prime Variables

Our simulation covers the boxes in figure 6 that are marked with a green color. From these boxes we derive five critical elements that are operationalized. The green boxes in figure 6 represents the core elements that we have chosen to simulate and we call these elements our prime variables. In Netlogo the prime variables are represented as states, and the figure 8 below illustrates the implementation of the states in the program. The five prime variables are **ResearchProjects**, **Funding**, **Accumulated-Revenues**, **AvailableAcademic** and **AvailableIndustry.**

Figure 8: The five prime variables of the Bridge model, represented by states in Netlogo.

Researchers from academia and industry join to form collaborative research projects in Bridge. The individual researchers are represented in the simulation as individual members. The members are divided into two categories which constitute our first and second prime variables: **AvailableAcademic** and **AvailableIndustry** (the number of researchers from academia and industry that are available to engage in innovation projects).

The aim of Bridge is to stimulate and enhance innovation in Europe. Thus, innovations are the principle outcome of Bridge. As innovations stem from research, we have set the third of our prime variables as **ResearchProjects** (which is a figure, simply representing the number of research projects running within Bridge at any given time). Each project generates research results of which some can be translated into innovations. The efficiency of this conversion is dependent on the quality of the research and the technology transfer system. However, in this simulation we have chosen to exclude the complexity of technology transfer and simplified the relationship between **ResearchProjects** and innovations as 1:1.

In order for Bridge to run research projects, the organization needs a financial budget. This element is translated directly into a monetary value with set currency and is the common denominator that links many of the components together. It is represented in the simulation as the prime variable, **Funding** and representing Bridge's cash flow.

An important aspect of this simulation is to analyze the long-term effects of income from intellectual property. We have set the final prime variable as **Accumulated Revenues**. This variable represents the accumulated revenues coming from intellectual property that Bridge research projects have generated. It is accumulated over the life span of the underlying intellectual property and it adds to the annual funding.

5.5 The basic idea of the model

The primary aim for the Bridge organization is to stimulate innovation, which has been operationalized into the prime variable ResearchProjects (represented as a state in Netlogo). In order to illustrate how the prime variables interact, we choose ResearchProjects as a starting-point and show its connection to the other prime variables.

In order to initiate research projects in the simulation, available members and money are needed. The members are represented by the two prime variables AvailableAcademic and AvailableIndustry. In other words, the value of these two prime variables must exceed a certain number for ResearchProjects to be generated. ResearchProjects is also dependant on money; without funding the expenditures with performing research will not be covered. This money is represented by the prime variable Funding.

When members enter research projects, they are no longer considered available. Thus the values for AvailableAcademic and AvailableIndustry decrease when these actors join research projects. However when a research project is dissolved, the members who were part of the project re-enter the state of being available (and the values of AvailableAcademic and AvailableIndustry increase).

The simulation starts off with a given amount of available members. However if new members are to enter the system, money is needed to cover the acquiring of these members. Parallel to this, money is also needed to support the available members that are already a part of the system.

As the sections above reveal, there are links between the prime variable Funding and the three prime variables ResearchProjects, AvailableAcademic and Available-Industry. The connections of the components are on the negative side of Funding since the three prime variables cost money to uphold.

On the positive side of Funding is the fifth and final prime variable, AccumulatedRevenues. This prime variable represents the money that Bridge intellectual property generates. Hence there is a connection between AccumulatedRevenues and Funding, but there is also a connection to the prime variable ResearchProjects. The more projects that are running in Bridge, the more innovations will be generated and thus more intellectual property and revenues will arise.

These are the basic connections between the prime variables in the model. However, there is a large number of other links, states, variables and flows in the model and these will be illustrated further in the section *The model in detail.*

We will also construct a second funding strategy in our simulation, where the terms for Bridge’s funding are different. In this scenario we exclude intellectual property as a source of income, and instead Bridge will receive money from industry partners that are involved in the research projects (illustrated in figure 9 on the next page). The idea is that involved companies will contribute with a certain percentage of the research budget.

This will lead to a scenario where the supporting companies basically get all revenues generated by Bridge research projects. Possible remaining revenues will go to Bridge, but will probably be so small that they can be neglected.

These previous sections describe what goes in and out of Bridge's financial budget. In our simulation the money that goes out is spent on acquiring new members and supporting new research projects. We can control how the money is distributed between the two alternatives, so that we can choose to fixate on either new members or new research projects.

There are a number of other factors that play their part in our simulation. In the following section we will present the model and all its components in detail.

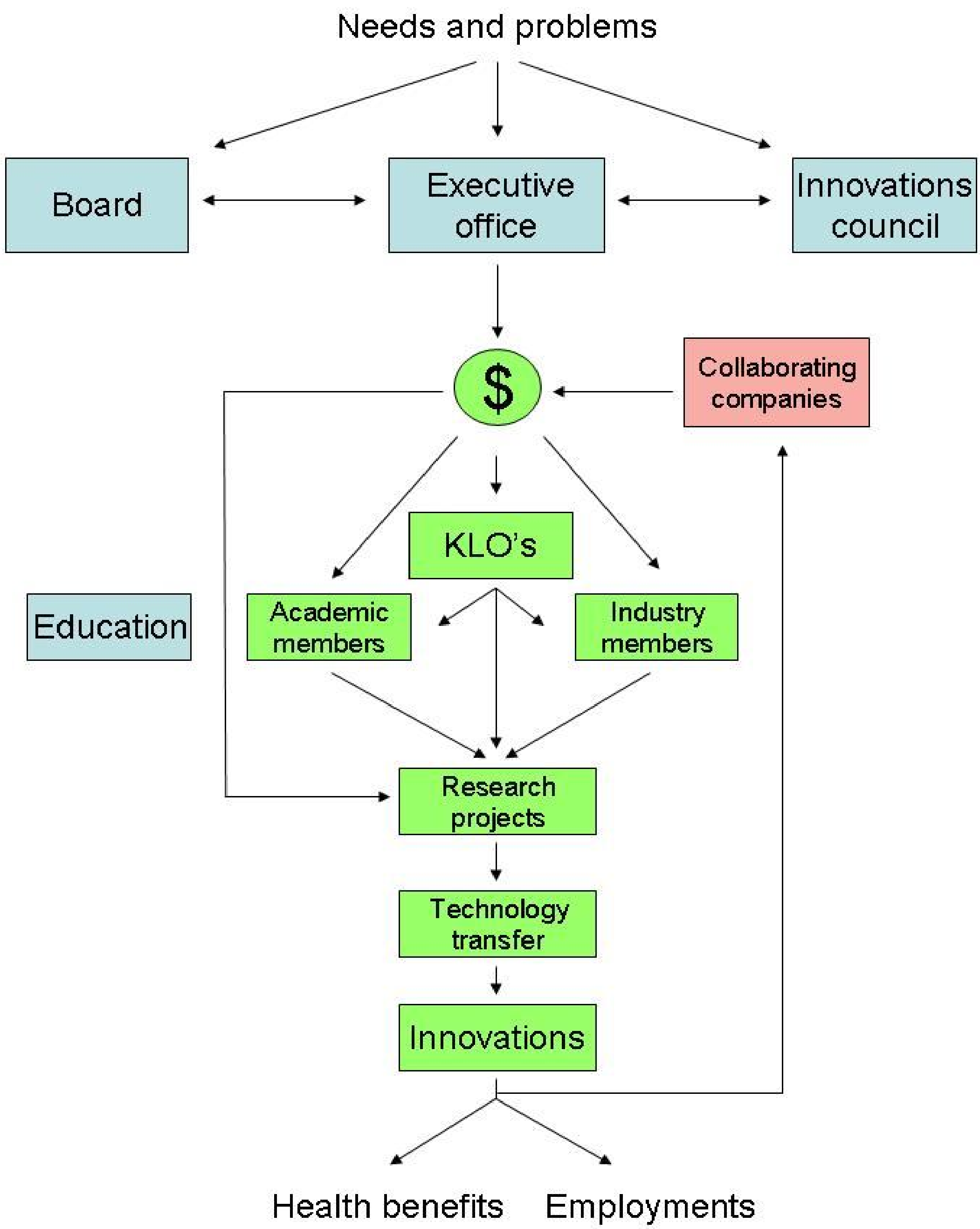

Figure 9: The second funding strategy of the model where funding is received from the collaborating companies. In this scenario, Bridge will receive no revenues from intellectual property.

5.6 The model in detail

The illustration in figure 10 shows the simulation in the System Dynamics view in Netlogo. The figure shows a number of components and its corresponding links (the arrows) with other components. This figure is quite messy and hard to understand, though the purpose of the figure is to show the complexity of our model.

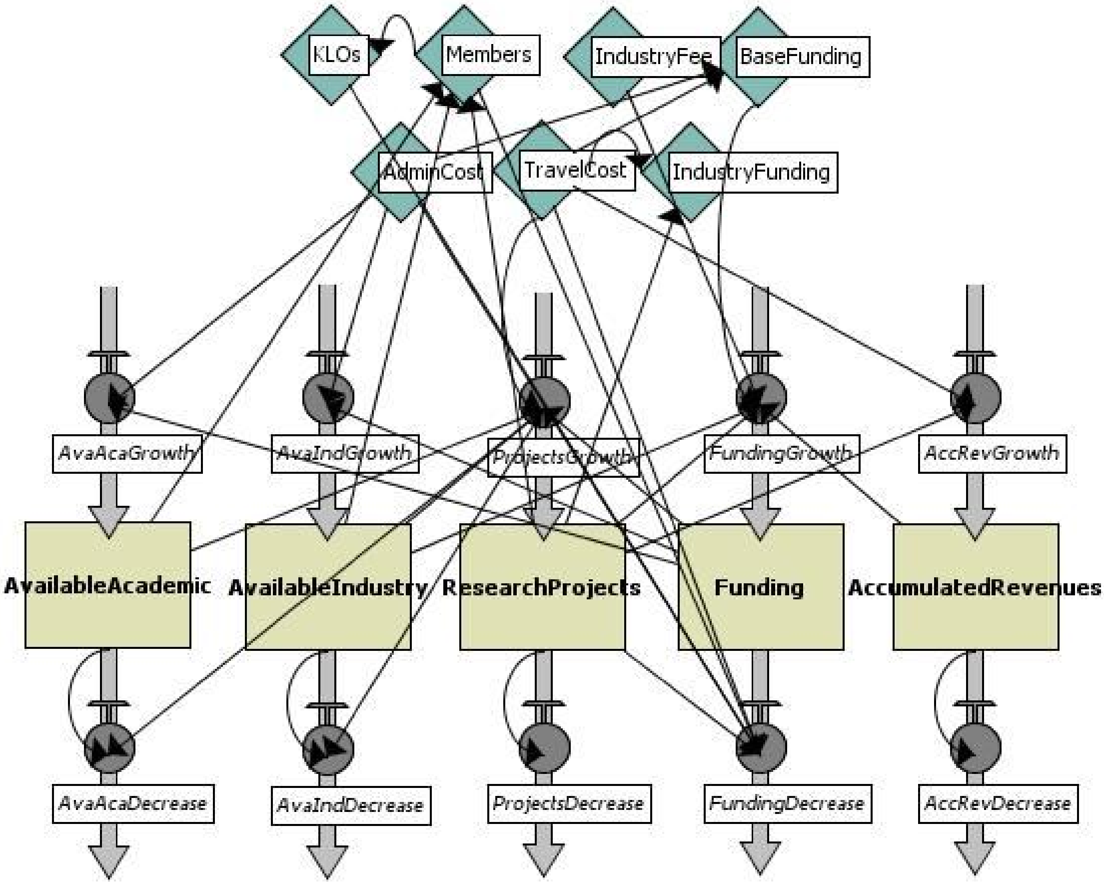

Figure 10: A view of the model in Netlogo.

The complexity in figure 10 leads to a need to simplify the model for the reader. The easiest way to do this is to get rid of all the links in figure 10 to get a better visual on the actual components of the model. This is illustrated in figure 11. Each of the model components in figure 11 will then be described in detail in the following sections to get a full understanding for the model. The mathematical formulas that connect the model components are presented as an appendix at the end of the report.

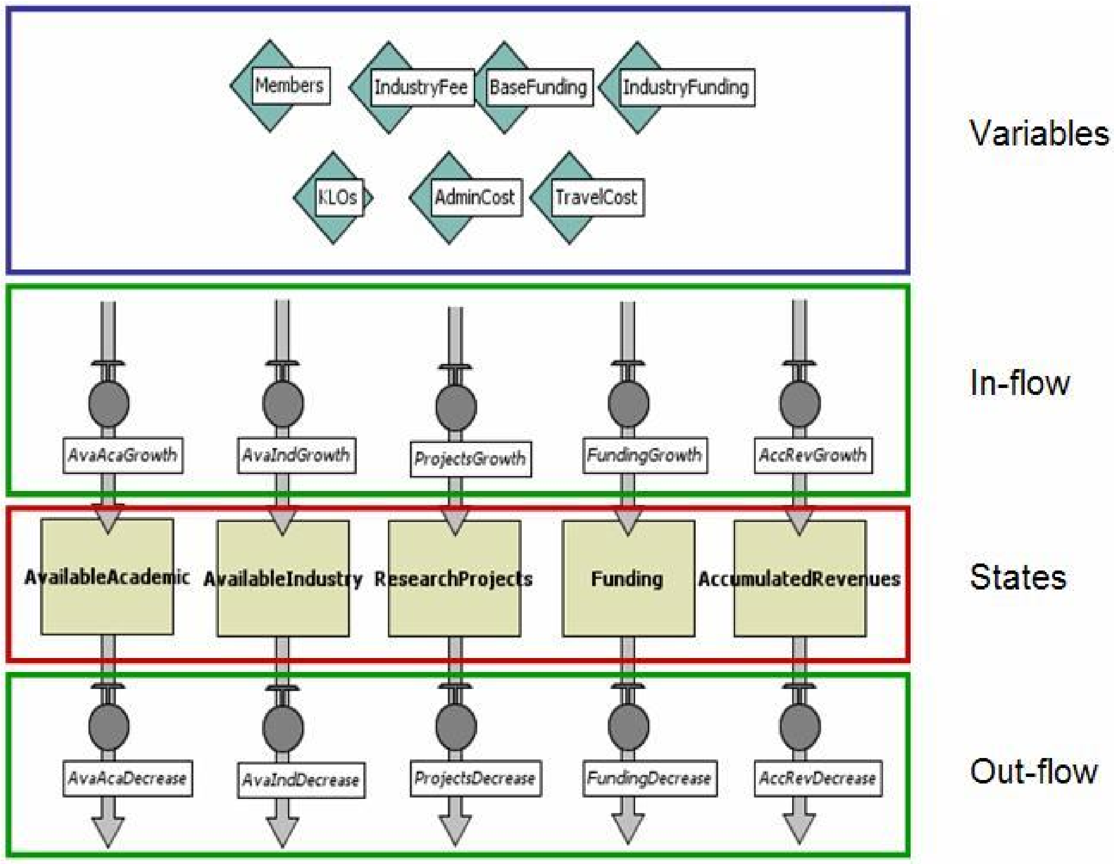

Figure 11: A view of the variables (blue rectangle), states (red rectangle) and flows (green rectangles) in Netlogo.

5.7 The model in detail: Variables

In our model we have eight variables and they will be described in the following sections.

5.7.1 AdminCost

AdminCost is a variable that constitutes blanket annual costs for the administration of signing up and maintaining Bridge members. Such expenditures could be costs for maintaining databases and legal costs for preparing agreements between the members and their affiliated organisations e.g. universities or companies.

5.7.2 TravelCost

Since Bridge is a virtual research institute and the members are located in different cities or countries, it is important to allocate funds and time for members to travel. *TravelCost* represents the annual travel costs for each Bridge member actively engaged in a research project. The value of the variable is estimated to € 3000. This is based on experiences from the Bridge-collaboration project (Paul Beatus personal communication).

5.7.3 ResearchCost

The value of the ResearchCost variable is set to € 100 000, a figure we have derived from interviews with a number of scientists throughout of Europe and from a conservative estimate from the Bridge organization[29]. This amount is meant to cover annual expenditure costs for each researcher involved in a research project, including salaries.

5.7.4 IndustryFee

The IndustryFee variable is a constant that is set to € 5000. It represents the annual membership fee for industry members to join Bridge. This is a preliminary value estimated by the Bridge organization.

5.7.5 BaseFunding

Any research organisation requires a starting capital or a minimum annual funding initially to operate and grow. The BaseFunding variable allows to modify the minimum annual amount of reliable funding required for running Bridge from e.g. a regional, state or EU financier. The BaseFunding is set as a percentage of all the theoretically possible projects that can be funded and it is dependent on the initial number of members specified by “InitialAcademic” and “InitialIndustry”. It represents the funding that is required to initiate and support a minimum number of research projects and to cover the initial member costs. The value of BaseFunding can be varied by using sliders for the initial amount of members and supported projects.

5.7.6 IndustryFunding

The IndustryFunding variable is an equation that computes the total annual amount of money that the industry members in the collaborations contribute to the ongoing projects. The money is contributed annually and can be varied by using a slider that decides how big percentage of the projects budgets that will come from the industry. This variable is applicable in the second funding strategy of our simulation, where a large part of Funding comes from industry companies that are involved in research projects (and basically all of the accumulated revenues go back to the companies).

5.7.7 Members

The variable Members is an equation that calculates the total number of members in the model at any given time, both academic and industrial. It adds up all the available academic members, industrial members and members who are in projects.

5.7.8 KLOs

This variable is an equation that calculates the total number of KLOs in the system. It is computed by dividing the current number of members in the system by the desired number of members per KLO. The value of members per KLO can be changed by using a slider.

---

[29] Survey on researchers (Appendix 2)

5.8 The model in detail: States and flows

As previously mentioned, there are five *states* in our simulation. To each of these states there are two flows (in and out). They are described in detail below.

5.8.1 AvailableAcademic

This is a state and it represents the number of academic members in the system that are not currently involved in projects, and is therefore referred to as “available”. The initial value for AvailableAcademic is varied by a slider, “InitialAcademic-slider”.

5.8.1.1 AvaAcaGrowth

The AvaAcaGrowth is a flow that increases the AvailableAcademic state. AvaAcaGrowth consists of two equations. The first equation calculates all the academic members that exit a project. When an academic member finishes a project they are considered available, and are therefore transferred back to the AvailableAcademic state.

The second equation calculates how many new academic members that can join the Bridge organization. This depends on a number of factors. The most important factor is how much funding is available, and this is represented by the state *Funding*. The equation takes into account the money that is allocated to AvaAcaGrowth from Funding, and then divides this sum with the costs for having an available member. The result gives the maximum amount of new available members that can join the organization.

When these two equations are added, the sum will be the number of new available academic members to join the system.

5.8.1.2 AvaAcaDecrease

As there is a flow that makes the AvailableAcademic state to increase, there is also a flow that makes it decrease. This is the AvaAcaDecrease flow, which is also composed of two equations.

The first equation describes the number of academic members that enter a new project. When an academic member enters a project they are not considered available anymore, and are therefore removed from the state AvailableAcademic.

The second equation describes the number of academic members that leave the Bridge organization. This number can be varied using a slider that sets a percentage of how many Bridge members which annually leave the organization. This parameter represents the natural turnover of members in Bridge.

5.8.2 AvailableIndustry

This is a state that works exactly the same as the AvailableAcademic state, though it represents the number of available industry members in the system. The initial value is set by using a slider.

5.8.2.1 AvaIndGrowth

This flow is calculated the same way as AvaAcaGrowth.

5.8.2.2 AvaIndDecrease

This flow is calculated the same way as AvaAcaDecrease.

5.8.3 ResearchProjects

This state represents the number of ongoing research projects in Bridge at any given time. In this simulation research projects directly correspond to innovations and thus, this variable is an important measure of the success of Bridge. The initial value for the state is set to 0.

5.8.3.1 ProjectsGrowth

This flow determines how many new research projects that are created annually. The number of new research projects depends on five parameters: Available members, research project size, assigned funding, efficiency and research project costs.

First of all, we have implemented an equation that calculates the number of available members in the system. This is to ensure that no more research projects are created than there are available members. The number of research projects also depends on how many members on average that are part of each research project, which is determined by a slider called MembersPerProject.

Second, the number of new research projects created is limited by the available amount of money and how it is distributed. The slider MemberProjectDistribution determines the distribution of how funding is distributed. We can vary the value of this slider and choose to allocate most of the money to either sign up new members, or invest in more projects. The money that has been allocated to create new research projects is divided by all the costs that are associated with running a research project (research costs, travel costs and salaries), which gives the number of theoretically possible new projects.

Finally, the number of new projects is dependent on the factor Efficiency. The value of this slider is adjustable and limits how many of all theoretically possible new research projects that are actually created. The value of Efficiency represents a number of factors that are hard to operationalize, which puts complexity on the parameter. When Bridge is put in practical use, Efficiency could depend on such factors as *personal chemistry between members, the number of face-to-face meetings between members, the research project's priority for individual members, the performance of the KLOs, the number of members that are part of each project team* and so on. Thus, Efficiency can be seen as a measure of how effective the KLO and the Bridge organization are.

5.8.3.2 ProjectsDecrease

This flow determines how many projects that are dissolved annually in Bridge. The number of dissolved projects is dependant on a slider we have named Decay. This value is adjustable and determines how long an average research project lasts. By multiplying the number of ongoing projects with the inverse of the expected research project length, the outcome is the number of annually dissolved projects.

5.8.4 Funding

The state Funding represents the amount of money that is available in the system. The initial value for this state is BaseFunding (see above).

5.8.4.1 FundingGrowth

This flow corresponds to the annual income in Bridge. It depends on four parameters: IndustryFee, BaseFunding, AccumulatedRevenues or IndustryFunding.

Industry members will pay an annual fee, which we have implemented in the flow. The annual fee is set to 5000 € per industry member and this figure is added from both the available industry members and those who are in a research project.

BaseFunding is also added to the Funding state each year. This is to ensure that a minimum level of members and research projects are supported.

Finally, AccumulatedRevenues or IndustryFunding are added. The first parameter is used when we run the first funding strategy of the simulation where Bridge acquires all research revenues. The later is used in the second funding strategy of the simulation where the involved companies assist with money for the research projects (and where they acquire all revenues).

5.8.4.2 FundingDecrease

This flow determines how much money that is spent each year by all Bridge activities. It depends on four parameters: KLOcost, AdminCost, ResearchCost and TravelCosts.

The KLO costs are calculated by multiplying the cost for each KLO by the number of KLOs in the system.

The AdminCosts are calculated by multiplying the value for a single member's administration cost with the sum of all Bridge members.

Finally the costs for running research projects are taken into account. These costs consist of research costs and travel costs. They are computed by multiplying individual research and travel costs with the total number of members in ongoing projects.

5.8.5 AccumulatedRevenues

This state adds the revenues from all projects. The initial value for the state is set to 0. The amount of revenues that projects generate, depend on a slider named ROI (Return of Investment). ROI represents a percentage of the research budget for each project. For each initiated project, this percentage is added to the state Accumulated Revenues, which thus is a representation of the money that is generated from Bridge's innovations.

5.8.5.1 AccRevGrowth

This flow is an equation that returns the revenues from the projects each year. It is calculated by adding the total research budget and multiplying it with the expected return. We have surveyed the approximate returns from commercialisation from a number of universities in Europe and we find that there is a great variation in how big this return is. As a comparison, the highest returns are around 1-1.5 percent of the university's total research budget, but at most universities the returns are far less[30,31].

5.8.5.2 AccRevDecrease

This flow is an equation that annually calculates the decrease in revenues. This is done by multiplying the value in AccumulatedRevenues with the inverse of PatentYears. I.e. if PatentYears is set to 10 years, AccumulatedRevenues will decrease with 10 percent per year. The parameter PatentYears represents the expected number of years that Bridge innovations will generate accumulated revenues.

---

[30] ASTP survey

[31] Danish universities and TTOs' statistics (Appendix 3)

5.9 The model in detail: Sliders

An important tool in the simulation is the "slider". These sliders define the basic settings of a simulation, and they can be manually adjusted at any given time during the simulation. The values of the sliders can be varied within a predefined range, i.e. the MembersPerProject slider has a range from 1 to 30 members per project. Below there is a list of all the sliders and a short description of each one of them.

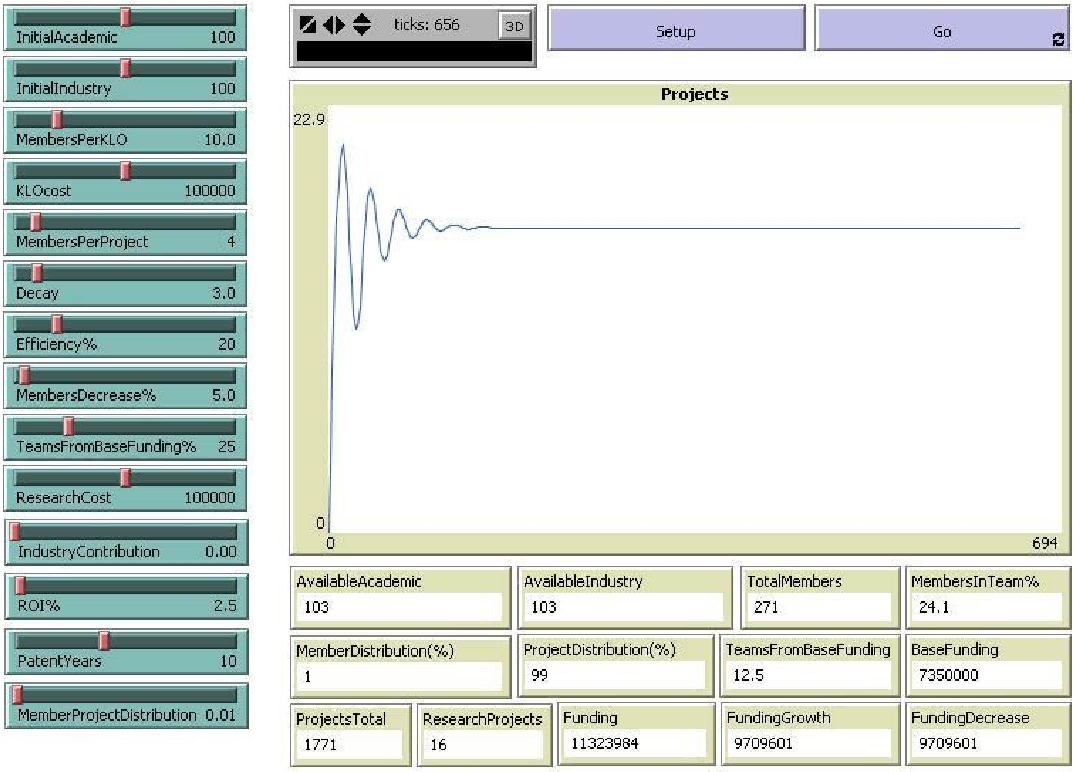

Figure 12: The Netlogo interface with the sliders on the left hand side.

5.9.1 Decay

This slider determines how many percent of the projects that are terminated each year. Thus, it defines the average length of a research project and has a range 1 to 30 years.

5.9.2 Efficiency

Defines how many of all theoretically possible new projects that are actually created and has a range from 0 to 100 percent.

5.9.3 IndustryContribution

This slider is only applicable in the second funding strategy of the simulation. It defines how big the industry contribution is in all research projects and has a range from 0.01 to 1. If it set to 0.01, one percent of the project budget will come from the industry partners. If set to 1, the entire projects funding will come from industry partners.

5.9.4 InitialAcademic

Defines the initial amount of academic members in the simulation and has a range from 0 to 200.

5.9.5 InitialIndustry

Defines the initial amount of industry members in the simulation and has a range from 0 to 200.

5.9.6 KLOcost

Defines the annual salary in euro for the KLO and has a range from € 0 to € 200 000.

5.9.7 MemberProjectDistribution

Defines the distribution of funding in the simulation and has a range from 0 to 1. If it is set to 0, all the funding will be allocated for new projects. If it is set to 1, all the funding will be spent on signing up new members. If it is set to 0.5, the funding will be shared equally between new projects and new members.

5.9.8 MembersDecrease

This slider defines the number of members that annually quit the Bridge organization and has a range from 0 to 100 percent.

5.9.9 MembersPerKLO

Defines the workload for the KLO, which is how many members a KLO is responsible for. The range for the MembersPerKLO-slider is from 1 to 50 members.

5.9.10 MembersPerProject

Defines the number of members in a single research project and has a range from 1 to 30 members per project.

5.9.11 PatentYears

This slider is only applicable in the first funding strategy of the simulation. It defines the average number of years that a research finding will generate revenues and has a range from 0 to 25 years.

5.9.12 ROI%

This slider is only applicable in the first funding strategy of the simulation. It defines the annual return of investment from every research project and has a range from 0 to 100 percent.

5.9.13 TeamsFromBaseFunding

Defines a minimum percentage of the theoretically possible projects that will be supported by Bridge and has a range from 0 to 100 percent. This percentage of projects is based on the initial number of members.

5.10 Basic parameter values

The Bridge model has now been translated into Netlogo and the software can start simulating different scenarios. As a starting point we have chosen a number of basic settings for the model's parametric values.

The idea behind these basic values is to have a point of departure for the simulations that mimic the situation at a typical university or research organization today. Below we will present the fundamental values for the parameters, followed by a justification for this value.

5.10.1 Simulation with funding strategy 1: Accumulated revenues

- The InitialAcademic-slider is set to 100. This value means that initially, there will be a hundred members from the academic sphere available for research projects.
- The InitialIndustry-slider is also set to 100. This value represents a hundred members from the industrial sphere that are available for research projects.
- The MembersPerKLO-slider is set to 10. This means that the KLOs will handle ten members each.
- The KLOcost-slider is set to 100000. This means that the annual salary for each KLO is € 100000 which is a conservative estimate.
- The MembersPerProject-slider is set to 4. This means that each research project will include four members. This is the average number of members in research projects in this field based on interviews with a number of scientists in Europe[32].
- The Decay-slider is set to 3. This means that each research project will run for three years, which is a value that is also derived from interviews with a number of scientists in Europe[33].
- The Efficiency-slider is set to 20%. This value is derived from interviews with a number of scientists in Europe[34], in combination with Bridge’s estimation of the KLOs effectiveness. Nevertheless, this is just an estimated value and there are a number of factors influencing this value (many of these factors are hard to operationalize).
- The MembersDecrease-slider is set to 5%. This means that for both academic and industry members, five percent will leave the system annually.
- The TeamsFromBaseFunding-slider is set to 25%. This value is a rough starting point and is inspired by EIT’s (European Institute of Innovation and Technology) “Call for proposals EIT-KICS-2009”[35].
- The MemberProjectDistribution-slider is set to 0.01. This means that 1% of Bridge’s funding will go to recruiting new members and 99% will go to forming new research projects.

---

[32] Survey on researchers (Appendix 2)

[33] Ibid

[34] Ibid

[35] EIT, KICs call

- The ROI-slider is set to 1%. This value is derived from a large group of different universities and TTO's, where an optimistic value for ROI has been calculated to 1%[36,37].
- The PatentYears-slider is set to 10. This means that the lifespan for each Bridge patent is ten years (the patent will generate money for ten years).

5.10.2 Simulation with funding strategy 2: Industry financing

- The IndustryContribution-slider is set to 0.1. This means that, for those research projects that are financed with money from industry, the industry will contribute with ten percent of the research budget.

[36] Danish universities and TTOs' statistics (Appendix 3)

[37] ASTP survey

5.11 Sensitivity analysis of the Bridge model

Sensitivity analysis (SA) is a great tool to assess the impact of individual parameters in the Bridge model. SA provides information about how big effect a given change in a single parameter has on the total outcome of the model. In the following section we present a series of sensitivity analyses performed on all the individual variables in the Bridge model implemented in the Netlogo software.

In our model, the main output is defined as the *state* **ResearchProjects** (representing the number of research projects). The aim of Bridge is to promote innovations. Since **ResearchProjects** is the prerequisite for innovations, we have for simplicity set the relationship between projects and innovations as a 1:1 ratio. Therefore the number of **ResearchProjects** is the principal output component to which we have compared each parameter's impact.

The sensitivity analysis for each parameter has been performed by adjusting its base value, to one of a number of fixed points in a given interval. These points represent a certain percentage of the parameter's original value, so they can be seen as distance measures. The percentage change for a given parameter is compared to the change of value for the state Projects. This method provides information about the parameter's sensitivity; if the percentage change for projects is larger than the percentage change for the single parameter, the parameter has a significant sensitivity[38]. The sensitivity value for each parameter is computed by dividing the percentage change for ResearchProjects with the percentage change for the parameter. This means that if the quota exceeds 1, the parameter has a significant sensitivity. All sensitivity values have been measured at a point at which the simulation has reached equilibrium.

The sensitivity analysis was performed according to two different methods. The two methods differ in how the percentage change has been calculated for the individual parameters. In the first method, the benchmark for each parameter is the value given in the ”Basic parameters”-section. The percentage change is then calculated according to this starting-point. Each parameter is changed to 50%, 90%, 110% and 150% of its original value. For example if a parameter's benchmark value is 5, a change to 50% will give the value 5 * 0.5 = 2.5. A measure for parameter sensitivity is given for each percentage.

On the next page is a list with the sensitivity value for each parameter using this first method. These values are applicable for both funding strategies of the simulation (with and without funding from industry partners). The next page also shows a graphical representation of the sensitivities' characteristics.

[38] System och Modell – en introduktion till systemanalysen, Gustafsson et al, p. 78

	50%	90%	110%	150%
Decay	0,49	0,34	0,3	0,27
Efficiency	0,49	0,34	0,3	0,27
IndustryContribution	0,08	0,08	0,08	0,08
InitialAcedemic	0,5	0,5	0,5	0,5
InitialIndustry	0,5	0,5	0,5	0,5
KLOcost	0,18	0,13	0,13	0,09
MemberProjectDistribution	0	0	0	0
MembersDecrease	0	0	0	0
MembersPerKLO	0,02	0,003	0,003	0,03
MembersPerProject	2	1,14	0,88	0,67
PatentYears	0,05	0,04	0,04	0,05
ROI	0,05	0,04	0,04	0,05
TeamsFromBaseFunding	0,45	0,47	0,47	0,45

Figure 13: The sensitivity value for each parameter given in the first step of the sensitivity analysis.

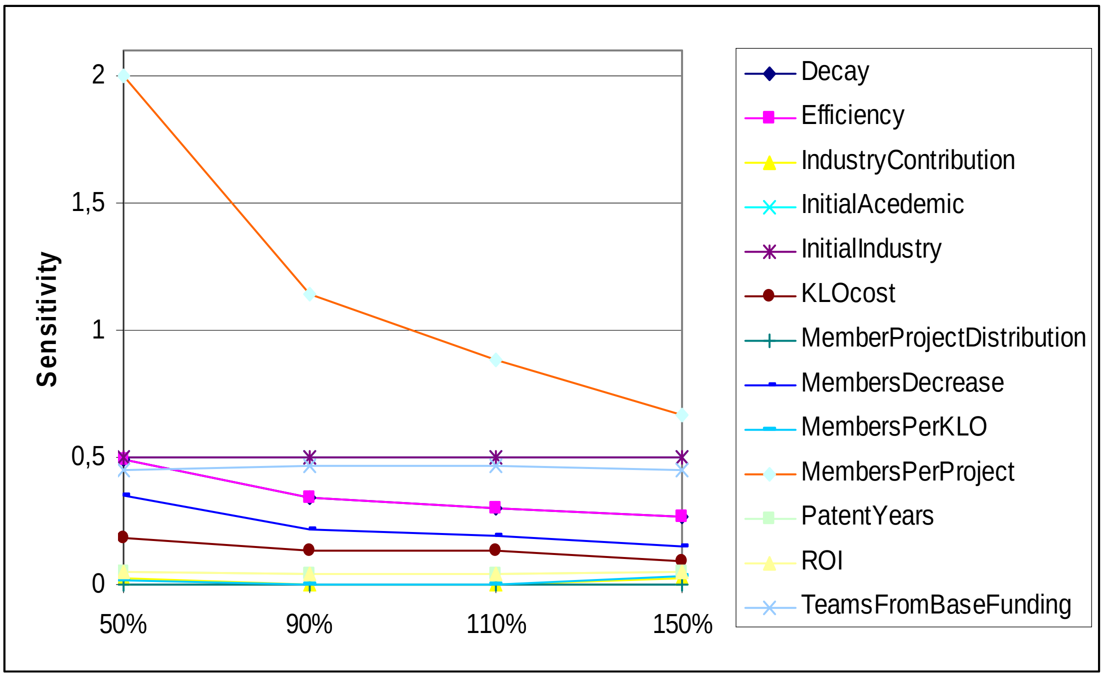

Figure 14: A graphical representation of the sensitivity values' characteristics for each parameter given in the first step of the sensitivity analysis.

The results show that a majority of the parameters have a sensitivity that is below the significance level. There is actually only one parameter that exceeds the limit and that is MembersPerProject. At 50 percent and 90 percent this parameter has the sensitivity values of 2.0 and 1.14 respectively. For the 50 percent value, this means that if MembersPerProject is increased with 1 percent, the number of research projects will increase with 2 percent.

Many of the parameters however, demonstrate a low sensitivity value. This means that these parameters have a low impact on the output of the model.

The results also show that most of the parameters have a linear sensitivity. This applies predictability to these parameters; no matter what value that is set, the output will respond with the same linearity. Therefore, a change of a linear parameter will always result in an expected output. Only MembersPerProject, Efficiency and Decay have a non-linear sensitivity. However, since only MembersPerProject displays a significant sensitivity, the non-linearity of Efficiency and Decay has no great importance. A limitation with this method is the way the percentage changes of the parameters are calculated. If the starting-point values for the parameters were to increase, the percentage changes would mean larger distance steps (and a decrease would lead to smaller distance steps). Thus, this method of the analysis is highly dependent on which basic parameter values that are applied to the model (the method does not cover the whole range of the parameters). Therefore, a second method of the analysis was tested.

In the second method, we use the pre-defined range for each parameter. In this case, a ten percent change of a given parameter is equal to a ten percent change of the parameter's range. For example, Efficiency has a range from 0 to 100 percent and the basic value for this parameter is 20%. An increase of 10% for this parameter would result in the value 30%. Thus the percentage change is measured relative to the range, rather than the basic value of the parameter.

The percentage points at which the parameters' sensitivities are calculated have been set to 1%, 25%, 50%, 75% and 99%. By doing this, the whole range for each parameter is covered.

On the next page is a list with the sensitivity value for each parameter using the second method (figure 15). There is also a graphical representation of the sensitivities' characteristics (figure 16).

	1%	25%	50%	75%	99%
Decay	6,03	1,55	0,71	0,47	0,38
Efficiency	4,53	1,45	0,78	0,57	0,43
IndustryContribution	0,75	0,91	1,19	1,68	2,84
InitialAcedemic	1	1	1	1	1
InitialIndustry	1	1	1	1	1
KLOcost	1,3	0,04	0,03	0,02	0,02
MemberProjectDistribution	7,15	3,28	1,87	1,31	1,02
MembersDecrease	6,6	0	0	0	0
MembersPerKLO	0,14	0,1	0,05	0,009	0,006
MembersPerProject	100,3	3,9	2	1,34	1
PatentYears	0,12	0,14	0,16	0,15	0,15
ROI	5,7	185	19254	349478	2712276
TeamsFromBaseFunding	1,38	1,37	1,37	1,38	1,37

Figure 15 The sensitivity value for each parameter given in the second step of the sensitivity analysis.

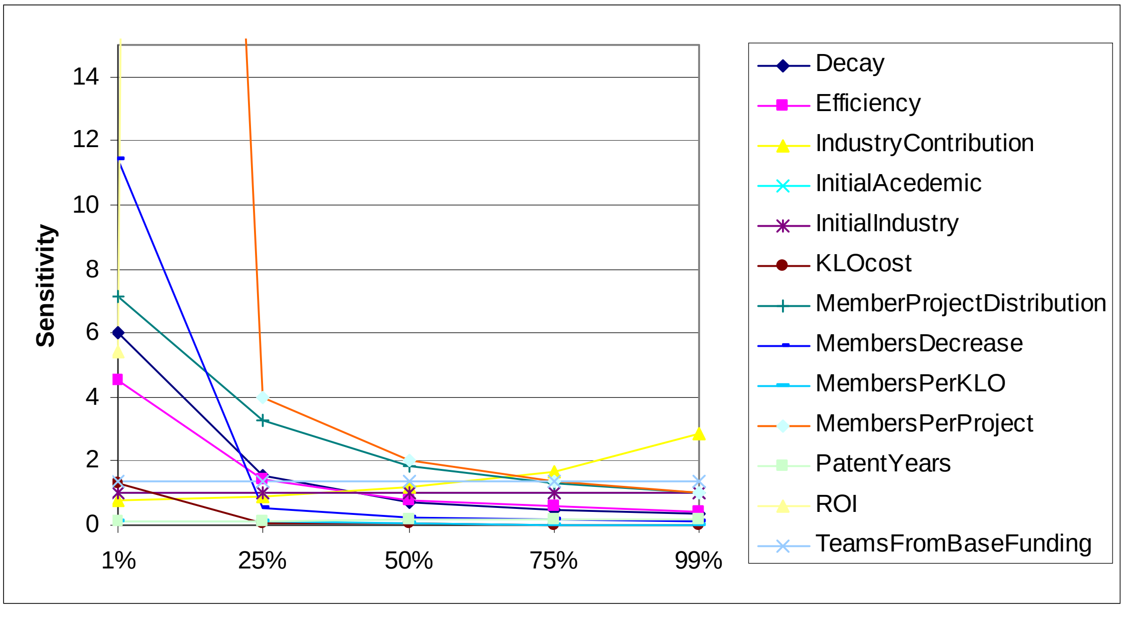

Figure 16: A graphical representation of the sensitivity values' characteristics for each parameter given in the second step of the sensitivity analysis.

For this method, the way of measuring significance used in the first method is not applicable. This type of sensitivity analysis is used to examine where in the given parameter range that the parameter is most sensitive. This allows for a cross reference with the first method of the sensitivity analysis, to see whether the basic parameter values are within a sensitive area.

The parameters that have a linear sensitivity are of low interest for this analysis, since the linearity makes these parameters' impact on the model output easily predictable. Therefore these parameters will not be further investigated.

As seen in figure 16, most of the parameters have their sensitivity peak in the first quarter of the range. In order to perform a detailed analysis of this range, a closer up of this range is presented below. Due to the different scales, two separate figures are presented starting with figure 17 below and followed by figure 18 on the next page.

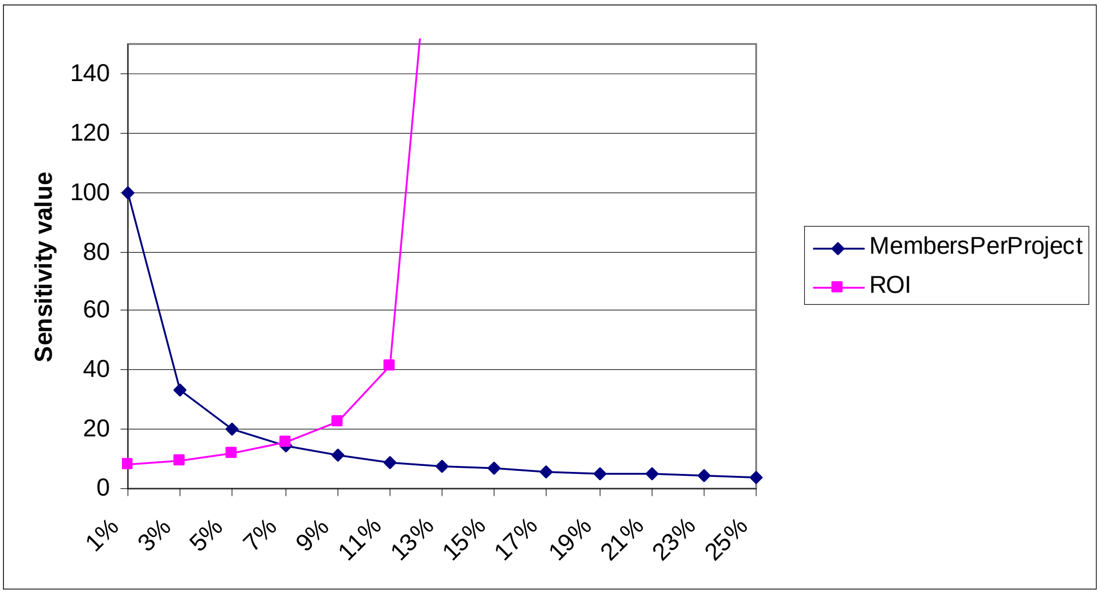

Figure 17: The sensitivity values in the second step for ROI and MembersPerProject in their first quarter.

The two most interesting parameters are displayed in figure 17; MembersPerProject and ROI (Return of Investment). These parameters have exponential characteristics for their sensitivity values. Thus, depending on how the basic value for these parameters is chosen, they can have a big impact on the model.

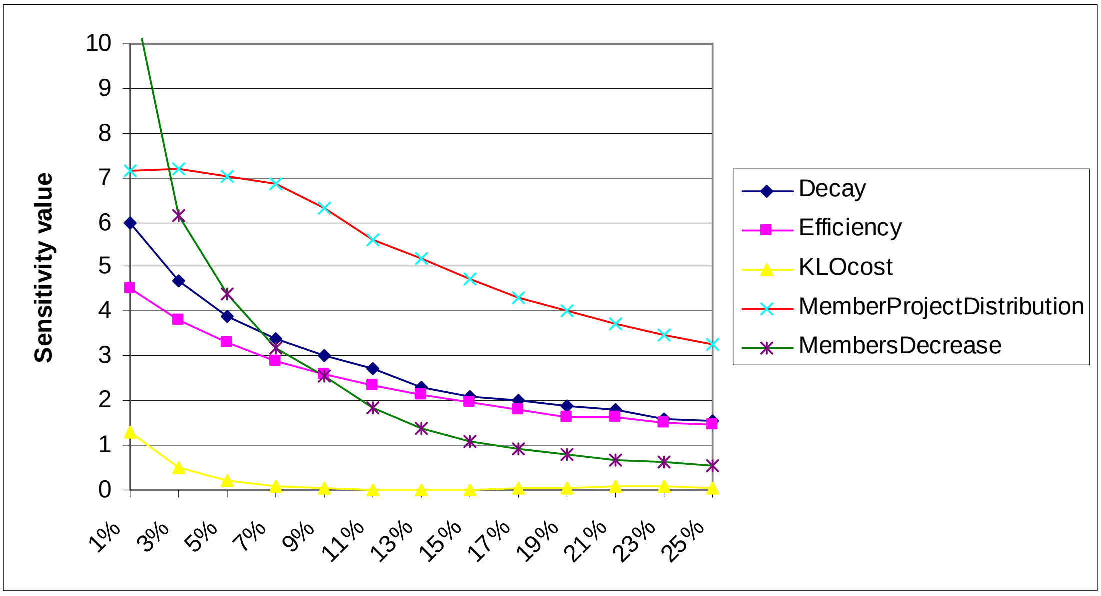

Figure 18: The sensitivity values in the second step for the remaining parameters that are sensitive in their first quarter.

For the remaining parameters, figure 18 shows that their sensitivity values are at a peak within the first ten percent of the range. After ten percent all the parameters have levelled out.

As mentioned previously, this method of the sensitivity analysis aims to investigate in what range a given parameter is the most sensitive and thereby learn whether our chosen basic parameter values are within the sensitive range. Figure 17 and 18 allow for such a cross-reference.

Starting with MembersPerProject and ROI, both of these parameters' basic values are situated in a close proximity to their most sensitive area. An increase or decrease of ten to fifteen percent would make a significant change in the sensitivity value (and a change of value for the parameters would generate a significant change in the output).

Regarding the parameters in figure 18, some of the parameters are situated in a sensitive interval. For example, the sensitivity value for MemberProjectDistribution and MembersDecrease will change drastically if its parameter value is adjusted by four percent.

Furthermore, Decay and Efficiency are situated in a close proximity to their most sensitive areas.

The basic value for the parameter KLOcost however, is situated far from its most sensitive region. The basic value would have to decrease with 49% for the parameter to move to the sensitive region.

One parameter that differs from the previously mentioned parameters is Industry-Contribution. Its sensitivity curve (figure 19) shows a different shape and has its most sensitive areas in the later parts of the curve. The basic parameter value is far from the most sensitive areas since it is set to ten percent.

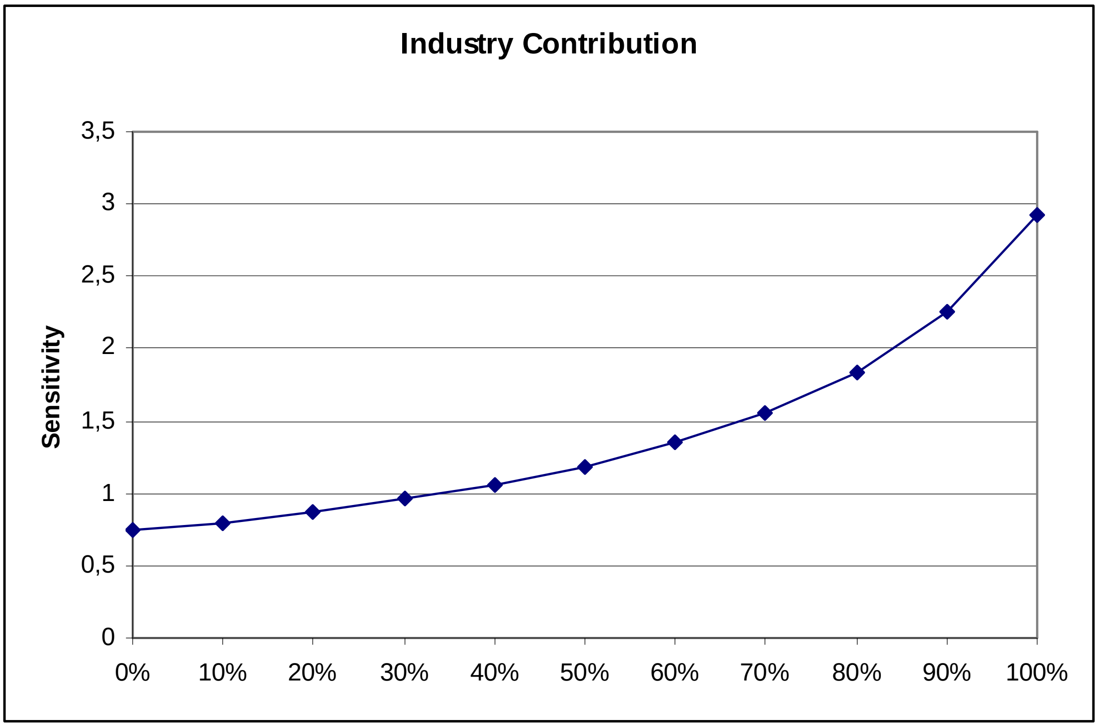

Figure 19: The sensitivity values in the second step for the parameter IndustryContribution.

5.12 Simulation Runs

This section will present a number of simulations of the Bridge model in Netlogo. In these simulations the output is represented by the state ResearchProjects, meaning the number of research projects running in Bridge at a given time. All simulations start at a point where all the parameters are set to their basic parameter values (see above). Based on this scenario the parameters that where found to be sensitive in the sensitivity analysis are modified as described above. This will show the parameters' actual effect on the aim of the Bridge organization; innovations as represented by research projects.

For each parameter there will be two simulation runs, one that shows the effect on Projects after 30 years and one that shows the effect on Projects when time goes towards infinity (equilibrium). The time span of 30 years has been chosen, since this will show how the model behaves within a close time frame. The runs where time goes towards infinity will illustrate how the model behaves when it reaches its equilibrium point, and show model trends in a longer time frame.

The model often demonstrates an oscillating behaviour before it reaches its equilibrium, and therefore the measure points at 30 years are often located on an oscillating curve. Thus there will be a clarification for each parameter value after 30 years, where on the oscillating curve that the value is situated.

For the basic parameter values, the measure point at 30 years generates **10.2** research projects. This value is situated on the top of the oscillating curve. When time goes towards infinity, the basic parameter value generates **14.4** research projects. These are the values that the parameter modifications are compared with. The basic parameter values are included in each of the following comparisons, but the basic values themselves need no further explanation.

The first parameter that is modified is Decay. Figure 20 shows the effect of the modifications on the model output.

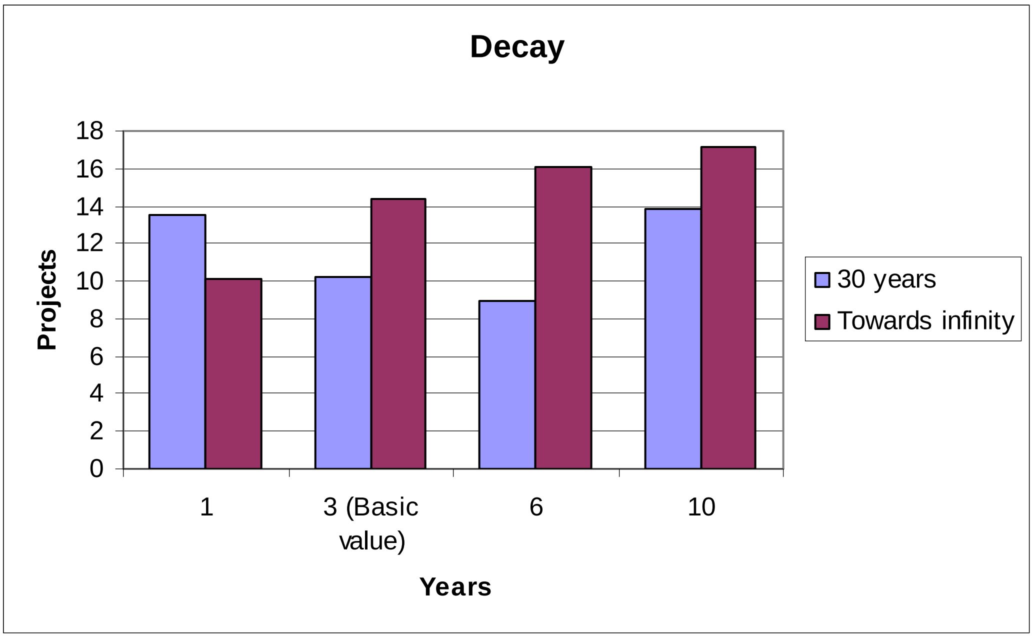

Figure 20: The effect of the parameter Decay on the model output.

For the value 1, which means that each research project lasts for one year, the measure point at 30 years generates 13.5 research projects. This value is situated on the top of the oscillating curve. When time goes towards infinity, the modification generates 10.1 research projects.

When Decay is modified to 6 years, the number of running research projects after 30 years is 8.9. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the modification generates 16.1 research projects.

For the value 10, the number of running research projects after 30 years is 13.8 and is situated on the bottom of the oscillating curve. When time goes towards infinity, the number of running research projects is 17.1.

The second parameter that is modified is Efficiency. Figure 21 shows the effect of the modifications on the model output.

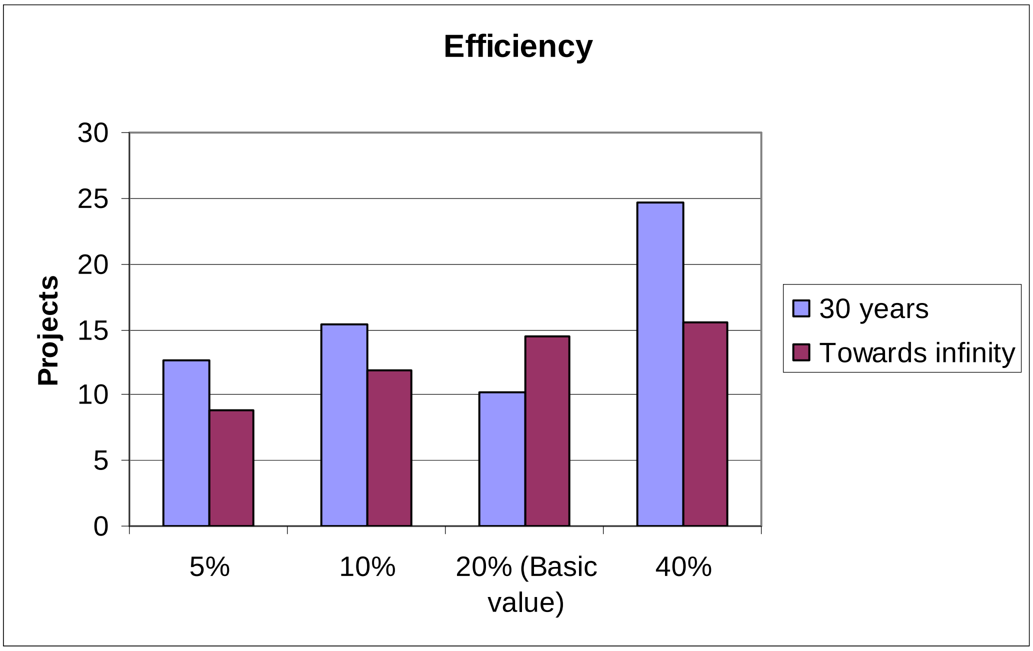

Figure 21: The effect of the parameter Efficiency on the model output.

For the value 5%, which means that five percent of all theoretically possible research projects are started, the measure point at 30 years generates 12.7 projects. This value is situated on the top of the oscillating curve. When time goes towards infinity, the modification generates 8.8 research projects.

When Efficiency is modified to 10%, the number of running research projects after 30 years is 15.4. This value is situated on the top of its oscillating curve. When time goes towards infinity, the number of research projects is 11.9.

For the value 40%, the number of research projects after 30 years is 24.6 and is situated on the top of its oscillating curve. When time goes towards infinity, the number of running research projects is 15.5.

The third parameter that is modified is MemberProjectDistribution. Figure 22 shows the effect of the modifications on the model output.

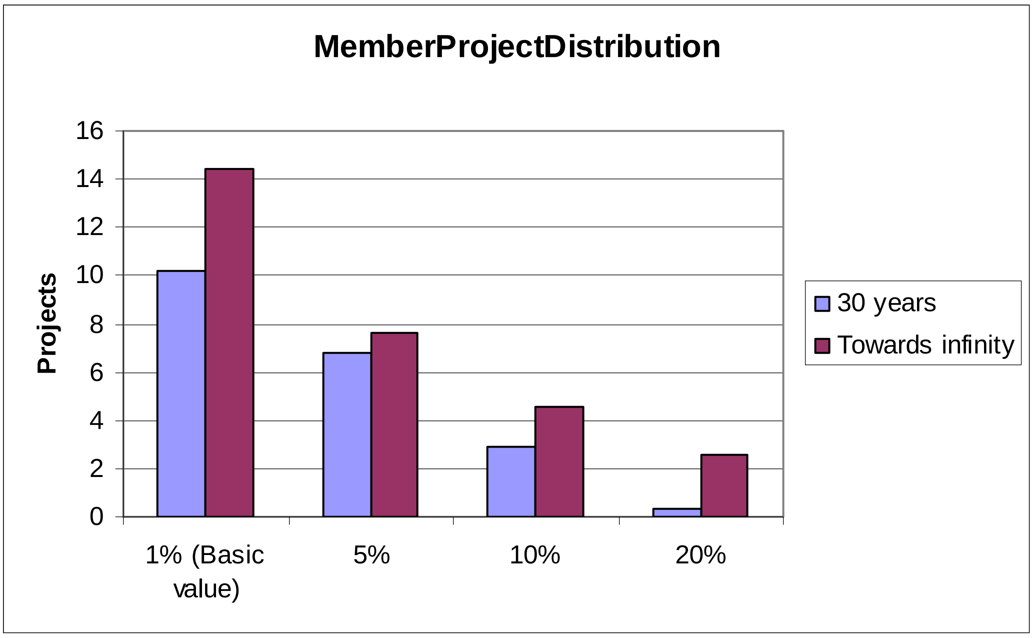

Figure 22: The effect of the parameter MemberProjectDistribution on the model output.

For the value 5%, which means that five percent of Bridge's funding will be allocated to assigning new members and 95% to creating new research projects, the measure point at 30 years generates 6.8 projects. This value is situated between the bottom and the middle of the oscillating curve. When time goes towards infinity, the modification generates 7.6 research projects.

When MemberProjectDistribution is modified to 10%, the number of running research projects after 30 years is 2.9. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the number of research projects is 4.6.

For the value 20%, the number of research projects after 30 years is 0.3 and is situated on the bottom of its oscillating curve. When time goes towards infinity, the number of running research projects is 2.6.

The fourth parameter that is modified is MembersDecrease. Figure 23 shows the effect of the modifications on the model output.

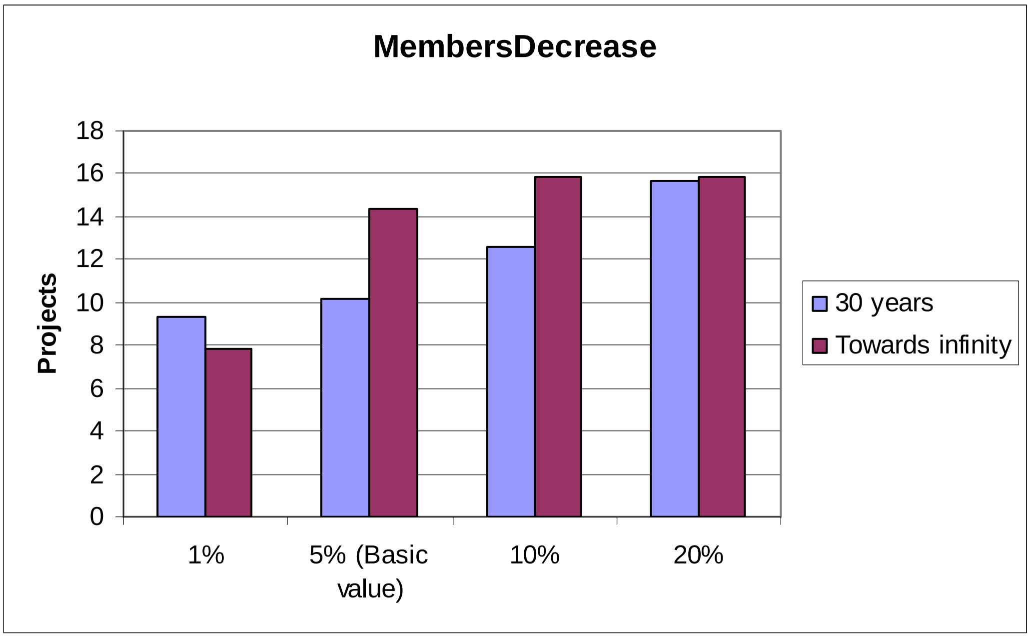

Figure 23: The effect of the parameter MembersDecrease on the model output.

For the value 1%, which means that there will be an annual one percent decrease of available members in Bridge, the measure point at 30 years generates 9.3 projects. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the modification generates 7.8 research projects.

When MembersDecrease is modified to 10%, the number of running research projects after 30 years is 12.6. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the number of research projects is 15.9.

For the value 20%, the number of research projects after 30 years is 15.7 and is situated in the middle of its oscillating curve. When time goes towards infinity, the number of running research projects is 15.9.

The fifth parameter that is modified is MembersPerProject. Figure 24 shows the effect of the modifications on the model output.

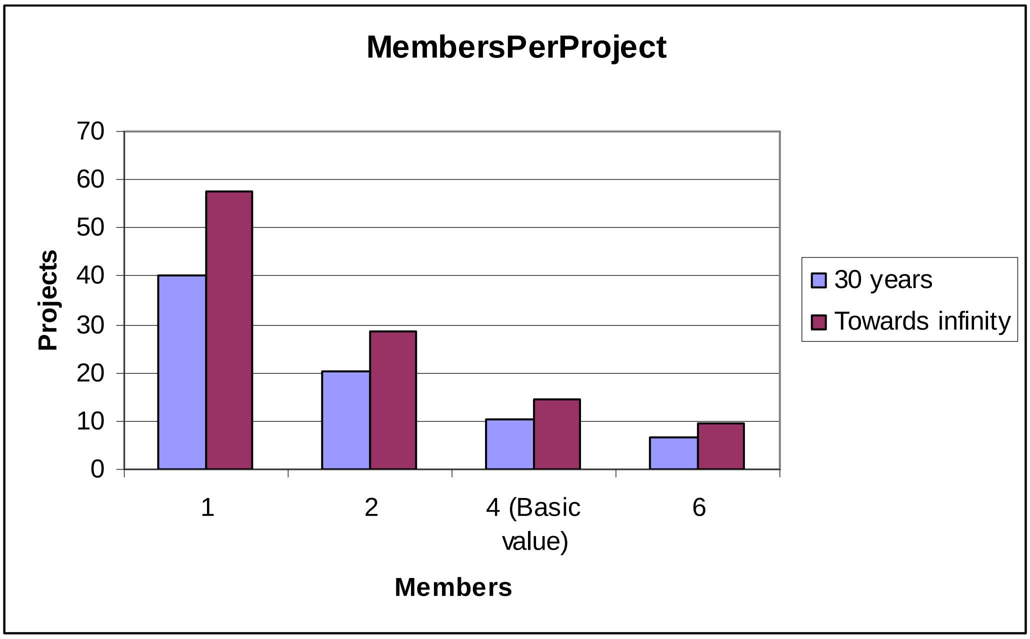

Figure 24: The effect of the parameter MembersPerProject on the model output.

For the value 1, which means that there is one member in each running research project, the measure point at 30 years generates 40.1 projects. This value is situated on the bottom of the oscillating curve. When time goes towards infinity, the modification generates 57.4 research projects.

When MembersPerProject is modified to 2 years, the number of running research projects after 30 years is 20.3. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the modification generates 28.7 research projects.

For the value 6, the number of running research projects after 30 years is 6.8 and is situated on the bottom of the oscillating curve. When time goes towards infinity, the number of running research projects is 9.6.

5.12.1 Funding strategy 1

The sixth parameter that is modified is ROI (Return of Investment). This parameter displays exponential characteristics for large values; therefore there are two separate figures for this parameter. Figure 25 shows the effect of the first four modifications on the model output.

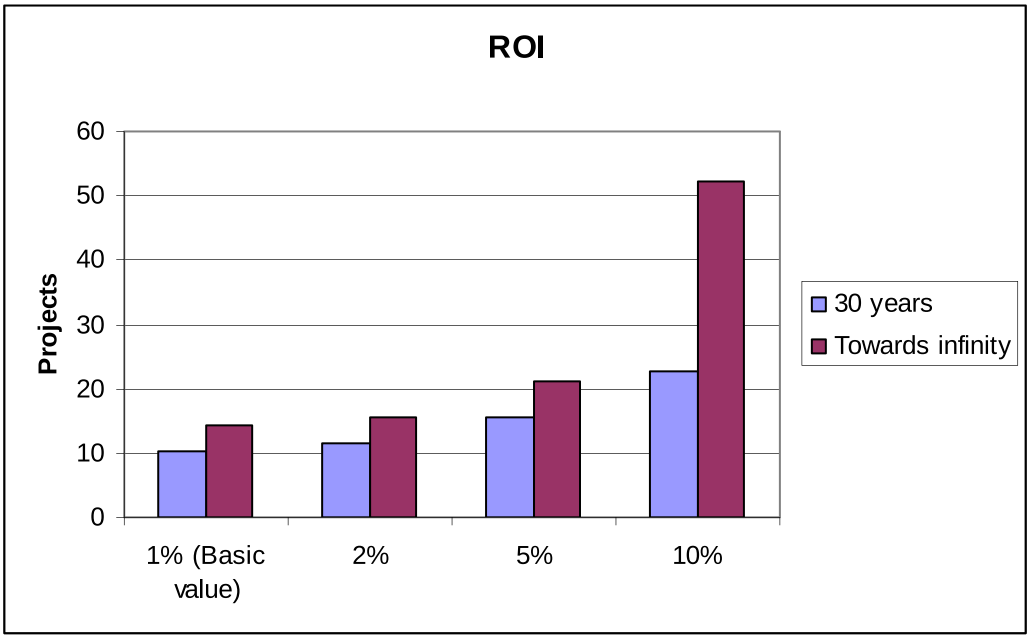

Figure 25: The effect of the parameter ROI on the model output.

For the value 2%, which means that the accumulated revenues for Bridge constitute two percent of their research budget annually, the measure point at 30 years generates 11.4 research projects. This value is situated on the bottom of the oscillating curve. When time goes towards infinity, the modification generates 15.6 research projects.

When ROI is modified to 5%, the number of running research projects after 30 years is 15.4. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the modification generates 21.2 research projects.

For the value 10%, the number of running research projects after 30 years is 22.6 and is situated on the bottom of the oscillating curve. When time goes towards infinity, the number of running research projects is 52.1.

If ROI reaches 14% it displays an exponential character, and therefore this parameter value for ROI will be investigated with an increased number of measure points. Figure 26 shows the effect of this parameter value after 30 years, 60 years, 100 years and 200 years.

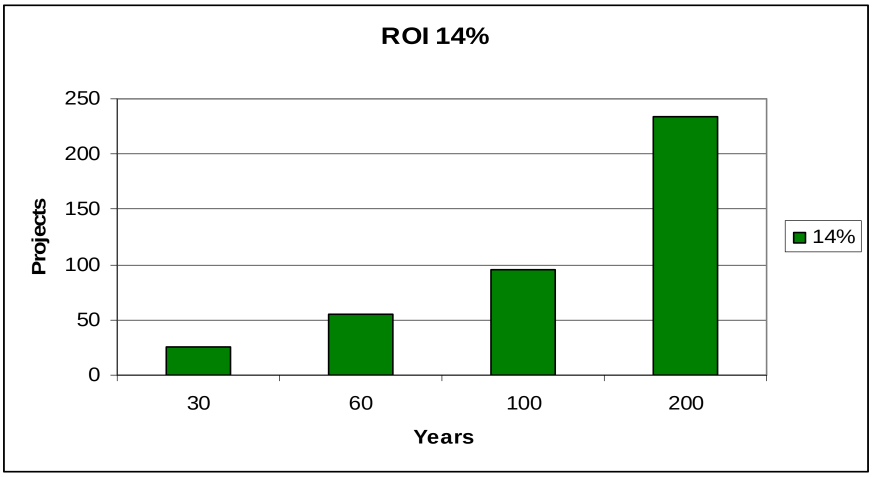

Figure 26: The effect of the parameter ROI on the model output when set on fourteen percent.

For this parameter there are no oscillating curves, the number of projects simply increase with time. When the measure point is set to 30 years, the parameter value generates 28.3 research projects. The remaining measure points show an exponential trend where the number of research projects increase in a fast pace in time. Figure 27 gives an illustration on the parameter's impact on the number of research projects when time goes towards infinity.

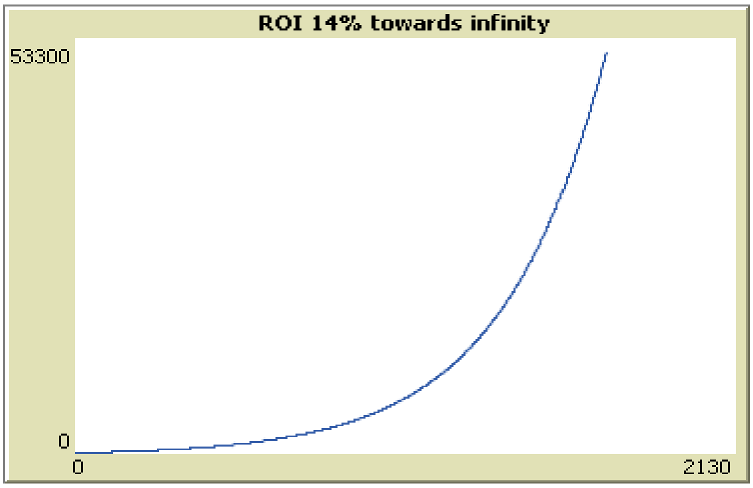

Figure 27: The effect of the parameter ROI on the model output when set on fourteen percent and time goes towards infinity.

The nature of the ROI parameter makes it highly interesting for the Bridge model. After a closer study of the model structure, a correlation is found between ROI and the parameter PatentYears (the number of years that each patent is valid). This correlation calls for further investigation on how the two parameters interact. A number of runs where the two parameters are varied show that ROI's exponential character is actually due to a certain quota between ROI and PatentYears. The empirical study shows that the exponential occurs when ROI multiplied with PatentYears is equal to or larger than the value 1.4. For example if ROI is adjusted to 7% and PatentYears is adjusted to 20, the product of these parameters equals 0.07 * 20 = 1.4. This quota was also valid in the previous section where ROI was set to 14% (and PatentYears was set to its basic value 10). Figure 28 provides an illustration of the scenario where ROI is set to 7% and PatentYears is set to 20, shown in the number of research projects when time goes towards infinity.

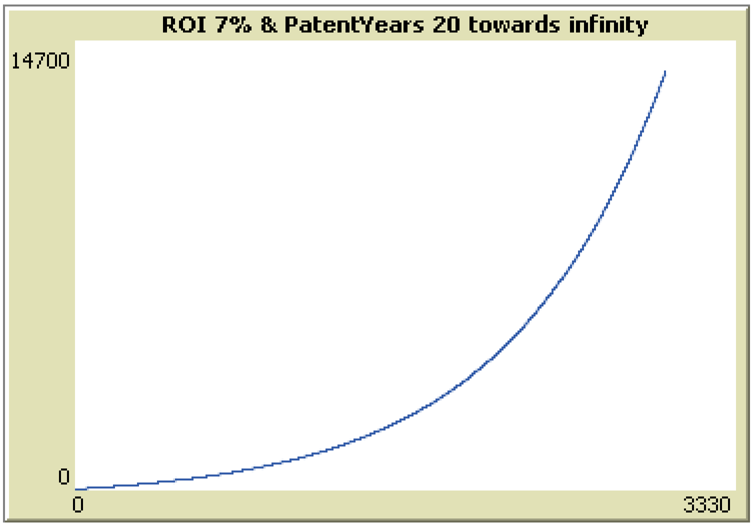

Figure 28: The effect of the parameter ROI on the model output when set on seven percent, PatentYears set to twenty and time goes towards infinity.

5.12.2 Funding strategy 2

In the following simulation, the second funding strategy of the model (where Bridge's projects are financed by industry members) is applied. Here the parameter IndustryContribution is modified. Figure 29 shows the effect of the modifications on the model output.

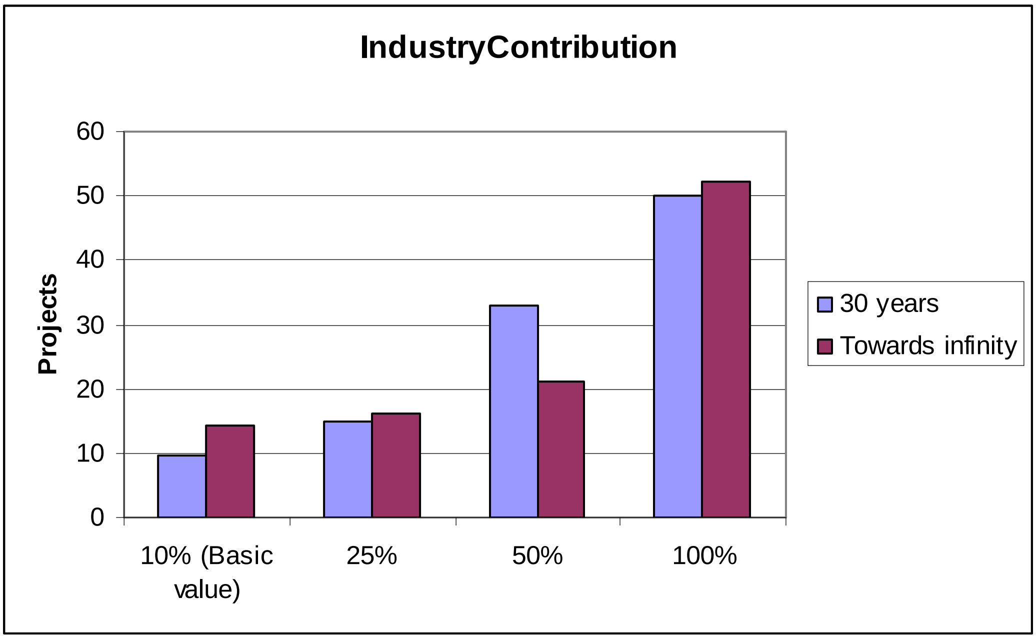

Figure 29: The effect of the parameter IndustryContribution on the model output.

When the parameter is set to 10%, meaning that industry members finance ten percent of each research project, the measure point at 30 years generates 9.7 projects. This value is situated on the bottom of its oscillating curve. When time goes towards infinity, the number of research projects is 14.4. These are the basic values for this second funding strategy of the model (10% is the basic setting for the parameter IndustryContribution).

For the parameter value 25%, the number of research projects after 30 years is 14.8. This value is situated in the middle of its oscillating curve. When time goes towards infinity, the modification generates 16.3 research projects.

When IndustryContribution is modified to 50%, the number of running research projects after 30 years is 32.9. This value is situated on the top of its oscillating curve. When time goes towards infinity, the modification generates 21.1 research projects.

Finally for the value 100%, the number of research projects after 30 years are 50.0. This value is situated in the middle of its oscillating curve. When time goes towards infinity, the modification generates the value 52.1 research projects.

In the last simulation run, the basic settings are applied once again. However, in this run the parameter TeamsFromBaseFunding is modified. This parameter represents the amount of money that is guaranteed by the main stakeholder or financier e.g. EIT, EU or a national source. For the scenario with the basic parameter settings, this money represents the total amount of Bridge's base budget (in Netlogo this money represents the percentage of all theoretically possible research projects that will be funded).

Another possible scenario is where the money from e.g. EIT represents 25% of Bridge's base budget. In this scenario the 25% funding is conditional that Bridge will provide the remaining 75% from other sources[39]. In Netlogo, this means that all theoretically possible research projects are funded. When a simulation run is performed according to this second scenario, the amount of research projects after 30 years is 82.8. This value is situated on the top of its oscillating curve. When time goes towards infinity the number of research projects is 44.5.

[39] Interview with Paul

Chapter 6

Analysis

The following sections are an analysis of the Bridge model and its parameters, as implemented in Netlogo. It starts off with an analysis of the model parameters and their measure points, with focus on the parameters that were identified as sensitive in the sensitivity analysis. It concludes with a comparison between the two funding strategies of the Bridge model (revenues from ROI versus IndustryContribution) and finishes with an analysis of the model limitations.

The analytical points generated in the sections below put focus on trends rather than actual numbers. The aim of the simulation is to study the way model parameters interact, rather than formulating absolute truths on how Bridge should give structure to their model.

The model implemented in Netlogo is a projection of Bridge. It constitutes a simplified way of looking at the organization and there are underlying factors to each of the components that the simulation does not show. However, the assumptions made in the model implementation are valid and formulating complements to the simulation results can reveal many of the underlying factors.

6.1 30 years

The simulation runs make observations on the model output at two measure points; the results after 30 years and the results when time goes towards infinity. The measure points at 30 years proved to be difficult to interpret, since the values unexceptionally are situated on an oscillating curve. This means that the parameters values differ, depending on the measure point. A parameter could have a completely different value after 35 years than its value after 30 years.

In Netlogo, these oscillations are due to an imbalance between the positive and the negative side of Funding (the state representing all Bridge's income and expenditures). When the negative side exceeds the positive side in value, the output curve transcends towards a negative direction (and the opposite thing happens when the positive side exceeds the negative side). This aspect manifests that the projected model in Netlogo, has no self-regulatory function. The program has no human factor that can analyze current trends at a given time in the model, and adjust parameter values so that an imbalance does not occur. This would hopefully not be the case when Bridge is put in practical use. There will be people responsible for planning the Bridge budget, which can counteract such oscillations. Fast shifts in the model output could be neutralized, for example with adjustments of expenditures and by regulating the amount of research projects that are initiated.

With this in mind, the analytical points in the following sections will be based on the long term results in the model (the output when time goes towards infinity).

6.2 TeamsFromBaseFunding

Much of how the Bridge organization will work when put in use, is dependant on the size of Bridge's budget. As previously mentioned, there are two possible scenarios for the approach on how to obtain funding for the first funding strategy of the model ((where Bridge is not dependent on industry contributions). In the first scenario, Bridge will obtain its entire budget from e.g. EIT. This is the case for our basic model settings, where TeamsFromBaseFunding is set to 25%. The second scenario would mean that the EIT contribution is based on specific conditions (namely that Bridge complements the EIT contribution with additional funds). The contribution from EIT would then constitute 25% of the entire Bridge budget, and Bridge would have to collect a remaining part of 75% of the budget.

The second scenario puts a lot more pressure on Bridge and forces the organization to formulate action plans for seeking financial grants. It means more work, but also an increase in the amount of research projects that are generated (all according to the aim of Bridge to stimulate the force of innovation). The simulation runs show that an increase for the parameter TeamsFromBaseFunding to 100% (25% from EIT and 75% gathered by Bridge) generates 44.5 research projects. Thus if Bridge manages to collect these grants, it would have a dramatic impact on the organization's results.
However, the sensitivity analysis for this parameter shows that it has a low and linear sensitivity. The linear characteristic for the parameter means that no matter where on the parameter's ratio the parameter value is situated, the model components in the system will co-operate in the same way. This is in line with the primary aim of the simulation: to make observations on trends and interactivity between parameters and their effect on the model output. Such observations are of higher value than a study of the simulation's numerical results. For example, there is no exact figure for how big Bridge's initial budget will be so the parameter TeamsFromBaseFunding is somewhat arbitrary. One thing that can be derived from the parameter is that an increased value for Bridge's base funding will lead to an increase of research projects.

6.3 Decay

The Decay parameter shows a low number of research projects when the parameter is set to low values. When the parameter is set to 1 (year), there will be an average of about ten ongoing research projects. If the Decay value is increased to an average project length of three years, the ongoing research projects increase to fourteen. It would be easy to make the assumption that having three years as an average project length would be far better than having an average project length of one year, since fourteen is a bigger number than ten. However, this is not entirely the case.

It is important to consider that with a project length of one year, the total number of projects that have been running during a time period of three years would be around 30. So having a project length of one year actually generates more than double the amount of research projects compared to having Decay set to three years. With this reasoning, it would probably be even better to have a research project length of just one day since this would lead to an enormous amount of research projects. However one have to take into account that when lowering the research project length, less time is given to perform research in each project and therefore less research findings will be generated.

The average research project length should therefore be balanced so that project lengths are as short as possible, while still generating qualitative innovations. The basic parameter setting for Decay is three years, and this is derived from our interviews with scientist. Three years seems to be a good estimation of the project length, but the best scenario for Bridge would be to decrease the project length and maintain the same quality of the innovations generated.

6.4 Efficiency

Efficiency is a parameter that defines how many research projects that are formed, out of all theoretically possible projects (given an amount of initial members and an initial budget). The basic value for this parameter is set to 20% and this means that out of a hundred possible research projects, twenty of them will actually be created. The sensitivity analysis shows that Efficiency is somewhat sensitive in the first quarter of the parameter's ratio, but loses its effect for higher values. The basic setting for the parameter lies within this first sensitive quarter, although close to its upper limit (25%). Thus a significant increase of the basic setting (>25%) would not lead to dramatic changes in the model output. A decrease of the basic setting however would have a large negative impact on the results, and therefore Bridge should strive for maintaining an efficiency of at least twenty percent.

In Netlogo, the research projects that are initiated will automatically generate a certain amount of intellectual property. As implemented, this intellectual property will be translated into innovations and a return of investment (represented by money). Therefore, Efficiency can be seen as a measure of Bridge's innovation capacity. Given this reasoning, the basic setting at 20% means that twenty percent of all theoretically possible research projects will form projects that generate innovations.

The parameter co-exists with the abilities of the KLOs. If the KLOs perform their gathering of members from academia and industry with excellence, it is estimated that Bridge's efficiency should reach the basic setting. Therefore, Efficiency can also be viewed as a measure of the KLOs achievements. In order to stimulate the KLO achievements, money is needed for the KLO salaries. With the basic settings, a salary of €100 000 per KLO generates a stable system output for the Efficiency value 20%. If the number of KLOs or their salaries were to increase, Efficiency could reach a higher value. However since the parameter loses sensitivity after the first quarter of its ratio, a significant increase of the number of KLOs or their salaries would lead to higher cost than it would lead to profitability.

6.5 MembersPerProject

The parameter MembersPerProject defines how many members that are part of each research project running in Bridge. The basic value for the parameter is set to 4, which means that there are four members active in each running project. When the parameter is processed in a sensitivity analysis, it is apparent that MembersPerProject has its sensitivity peak within the first 25% of its ratio. The parameter displays one of the highest sensitivities in the projected Bridge model and is therefore highly interesting.

In the simulation runs, the results show that a decrease for the parameter leads to an increase for the amount of research projects. According to the simulation it would be better to have one member per research project than to keep the basic parameter setting (the basic value of 4 generates 14.4 projects and the value of 1 generates 57.4 projects). However, a line of reasoning on this matter is that if research projects are run by a lower number of researchers the force of innovation might suffer. To run research projects with only one member per project would also contradict a fundamental goal for the Bridge organization – to stimulate collaborations between different researchers who each hold their own valuable competence. It is this kind of collaborating that helps define Bridge as a successful virtual organisation and a powerful force of innovation. Thus, the results in the simulation runs for this parameter are somewhat misleading. If the simulation model was to be extended, an addition could be that the parameter MembersPerProject connects to an "innovation-factor". This could be done in Netlogo by multiplying the parameter with the value for ROI (Return of Investment). This would mean that an increased number of members per project would lead to an increase in accumulated revenues (symbolizing innovations and representing the amount of money that these innovations generate).

An extension of the model could also include a connection between MembersPerProject and the parameter Efficiency. The more members that are included in research projects, the harder it will be to form logistics for each project. An increase for the parameter (e.g. 20 members per project) would make it complicated to arrange face-to-face meetings where all members are present, and there could be difficulties with issuing well-defined roles for each researcher. It is also likely that the individual researcher will have other commitments besides Bridge, which means that not all researchers will be constantly active in their given research project. Thus a large value for the parameter MembersPerProject could also have the effect of increasing the parameter Decay (a project with a large number of researchers with a low active participation could mean that it would take longer to reach research results).

6.6 MemberProjectDistribution

The MemberProjectDistribution parameter can have a big impact on the model output. The sensitivity analysis shows that the parameter is highly sensitive in the first quarter of its range. Since the basic parameter value is located in this quarter, small changes in the parameter will lead to big changes in the model output.

The basic parameter value is set to one percent and this generates 14.4 research projects. If the value is changed to five percent, the amount of research projects is halved. Furthermore if the parameter value is doubled to ten percent, the research projects decrease to the value of 4.6 research projects. It is clear that this parameter is extremely sensitive in the first ten percent of the parameter range.

As the parameter value increases, the number of research projects decreases and the number of members increases. If the basic parameter value was set to 50%, meaning half of the funding goes to members and half to research projects, Bridge would have a large amount of members and only about one research project running per year. So for Bridge, there will be no interest in setting this parameter to a high value.

When the basic parameter value is set to one percent, a large amount of research projects is encouraged and the number of members is kept on a lower priority. So the setting of this parameter falls in line with the Bridge vision to enhance the innovation force in Europe (represented in our model by the number of research projects running in Bridge).

6.7 MembersDecrease

The sensitivity runs for MembersDecrease show that the parameter is sensitive between zero and five percent; any value above this interval has little or no influence at all in the model. Needless to say, there would be a negative effect on the Bridge organization if 99% of its members exited the organization each year. As the model is built, Bridge will have enough funding to acquire new members to make up for those that exited. This is a limitation in the model, but then again, it is not reasonable to believe that actually 99% of its member would exit the organization each year.

A reasonable number for how many researchers that annually exit the organization should be between five to ten percent, and therefore the basic parameter value is set to five percent. If the parameter would be set to a value that is lower than five percent, a large increase in available members would occur (members who are not involved in a research project). Available members cost money in upkeep (KLO and admin cost) and therefore Bridge should strive to maintain their MembersDecrease level equal to or above five percent.

6.8 ROI

The ROI parameter is applicable in the first funding strategy of our model where accumulated revenues are used. The ROI parameter stands for Return of Investment and in our case the return of investment in research projects. The basic parameter value is one percent, which means that for every euro that is spent on Bridge research projects, the return will be one cent. The basic parameter value lies in close proximity of its most sensitive interval, and a small increase in ROI can make a large difference (a change of the parameter from one to ten percent leads to an increase from 14.4 to 52.2 research projects).

The most interesting part of the simulation runs made with ROI is the 1.4 quota between ROI and PatentYears where the number of research projects follows an exponential curve in time. Even though PatentYears is not sensitive in itself, an increase in PatentYears makes it possible to decrease ROI and still obtain the same results.

The basic parameter value of one percent of ROI is adapted from a number of TTO's and universities across Europe. The TTO's with the highest ROI value today has a value from one to one and a half percent. This value is far from fourteen percent, but there are a number of factors that can increase this value.

First, the Bridge organization will at all time know market needs that are present in Europe. Knowing the market needs will generate better innovations and make them easier to transfer to the market.

Second, Bridge has something that regular universities and companies don't have; the KLO. With the KLOs know-how of the market and researchers in his or hers close geographical area, the KLO will be able to match the best suited researchers for every research opportunity that arises.

Third, Bridge will only use the most prominent and suitable TTO's in Europe to maximize the revenues for each research project. To assure this, Bridge uses its TTO unit that keeps track of the every research project and their research, to be able to match the research findings with the most suitable TTO's.

Last, by using an effective approach to the choice between licensing fees and equity positions in start-ups, Bridge can optimize their revenues from intellectual property. There is no absolute truth to which way to go, but Bray and Lee argue that using equity positions in start-ups generates higher revenues. With more research made on the subject, Bridge could use a strategy in the matter that generates a higher value to the ROI parameter and also a longer patent length.

These four factors could make a large increase to the ROI value in Bridge, but how large is impossible to say. Also, if the value for PatentYears would increase to about fifteen years, a ROI value of a little less than ten percent would be needed to get to the 1.4 quota.

6.9 Industry Contribution

This parameter is applicable for the second funding strategy, where Bridge industry members finance a given proportion of each research project. The basic setting for the parameter is 10%, meaning that ten percent of the budget for each project is contributed by industry. Industry Contribution is the only parameter in the sensitivity analysis that displays its sensitivity peak in the last quarter of its ratio. The basic setting is situated outside this ratio (in the opposite quarter), which suggests that Bridge should put efforts on increasing the value for the parameter.

The simulation runs also show that if the value for Industry Contribution is increased, more research projects are generated. According to the simulation, an optimal scenario would be where the whole budget for each research project is contributed by industry (where the value for the parameter is set to 100%). This would generate 52.1 research projects, in contrast to the 14.4 projects that the basic parameter setting generates. The fact that the basic setting for this parameter generates a considerably lower amount of research projects, suggests that the choice of value for the basic setting could be revised.

However, the results given in the simulation runs leave out some aspects that should be taken into consideration. As mentioned previously, the second funding strategy of the simulation model results in a loss of accumulated revenues for Bridge. A valid assumption is that if a company finances the most part of a research project, this company will want the right to claim most of the profit generated by the project. Also, the more financing that is contributed by industry, the less power Bridge will have over its research projects. Consequently if Industry Contribution is set to 100%, Bridge compromises the right of calling research projects their own (the research projects would still be called Bridge projects, but Bridge's influence on the projects would be limited).

6.10 Comparison of the two funding strategies

This section will make a comparison between the two funding strategies of the model. A simulation run of the first funding strategy with all parameters set to their basic value, generates an output of 14.4 research projects. When the second funding strategy is run (also with all parameters set to their basic value) the exact same output is generated. A closer study shows that the parameters ROI and IndustryContribution are directly correlated. When the values for the two parameters are modified, they display the same output for each measure point (when a factor of 10 is multiplied with IndustryContribution). This is illustrated in figure 30, which shows the correlation of the two parameters.

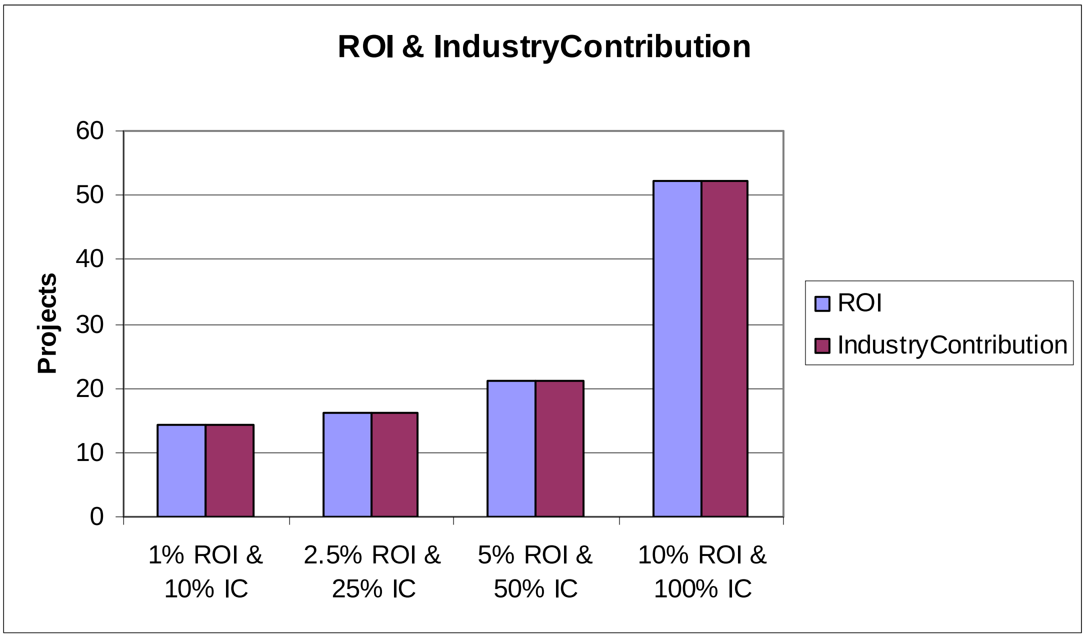

Figure 30: The comparison between ROI and IndustryContribution of their effect on the model output.

The reason for this correlation is found in the model structure; the two parameters are both defined by a certain percentage of Bridge's research budget. Industry-Contribution represents a proportion of the budget for each research project. If the parameter is set to 10%, the numerical value of IndustryContribution will be calculated as 0.1 multiplied with the given research budget. ROI is calculated the same way, with the addition of the parameter Patent Years. For example if ROI is set to 1% and Patent years is set to 10 (its basic value), ROI will be multiplied with a given research budget 10 times (the return of investment is valid for the 10 following years). This equals the factor for IndustryContribution given above (both parameters are multiplied by the factor 0.1 with the research budget) and explains the correlation between the two parameters.

This correlation suggests that it makes no difference which of the two funding strategies that Bridge chooses to follow. However, there are underlying factors that should be taken into consideration. As mentioned before, a large proportion of contribution from industry would lead to a loss of control for Bridge over the organization's research projects. If the value of the parameter IndustryContribution exceeds 50%, industry partners would hold a majority ownership of each research project. With this line of reasoning, the second funding strategy of the model can be argued to have a maximum peak level at 50% (values above would constitute a risk for the research projects losing their definition as Bridge projects). In the simulation, the maximum peak level is set to 100%. This would mean that industry holds total control over the research projects initiated within Bridge. Such a scenario is far from desirable, so the maximum peak level in the simulation does not correspond to the actual maximum peak.

The first funding strategy of the model where ROI is applied does not contain such a maximum peak level (whether set to 50% or 100%). The parameter ROI constitutes a percentage of the research budget, but this percentage is solely dependant on the quality of the work performed by actors in Bridge. If the performance of the KLOs, the researchers, the TTO's etc. is optimized, there is no concrete limit for the amount of return of investment for Bridge's intellectual property. This argues for that Bridge should choose to adopt the first funding strategy of the model. It would mean that Bridge fully owns the research projects initiated within the organization and there would be free handling of the innovations that the projects generate.

However, an argument for having a large amount of the research projects financed by industry would be that this source of income is more secure than applying for grants. There would be signed documents from both Bridge and the given industry partner, where there are guarantees for contributing with a stated money figure. This way of financing research projects would also release some pressure on Bridge, by removing demands of a lucrative return of investment. Furthermore, this way of financing research projects is also more secure in the start up phase of Bridge, since money is generated right away. If the first funding strategy of the model was to be chosen, Bridge would not generate any money before the first innovations are ready to go to the market, and that can take as long as ten years.

6.11 Model limitations

It is important to keep in mind that, while our model results point out some interesting aspects of the Bridge organization, the model also has its limitations. These limitations are hard to avoid, since it is impossible to project every aspect of the actual Bridge organization to a computerized model. A few of these limitations will be described below.

MembersPerProject tells nothing about the quality of the research projects. It is reasonable to think that a four man project would achieve better results than a one man project given the same time frame. A question can arise whether a ten man project is better than a four man project. This is hard question to answer and the answer differs from time to time. But putting together a ten man project is definitely a harder task than putting together a four man project, and this is not taken into account in the MembersPerProject or Efficiency parameters.

The same reasoning goes for the parameter Decay. This parameter’s effect on the quality of the research findings is hard to predict, but a one year project’s research finding will probably be of less value than a research finding from a ten year project.

It is hard to operationalize the indirect effects of all these factors, but it is important to have these effects in mind when performing simulations with the model.

Last, the financial budget in our model of the Bridge organization adjusts itself when the costs increase and decrease. This leads to the fact that the model could behave in a different way if the budget was to be fixated.

Chapter 7

Conclusions

This report has concluded that Bridge fulfils the criteria for being a successful network that holds virtual organizations. A comparison with the previous research made by VOSTER gives the conclusion that Bridge’s network and virtual organizations contain all the key positions that are needed to generate an innovative environment.

The CWA framework provides further imaging of Bridge and highlights factors that should be considered when giving structure to Bridge’s network and its virtual organizations. Many of these factors work as a complement to the simulation. They are excluded from the simulated model, but will yet be present when the Bridge model is put in actual use.

For the simulation part, several assumptions have been made on how model components interact. These assumptions are based both on the report’s empirical study of Bridge’s structure, and facts given by interviews and statistics.

A sensitivity analysis shows that there are a number of parameters that are sensitive and have a significant impact on the model. These parameters should be taken into careful consideration when Bridge formulates the balance between the components in the system.

One of the most important functions of the simulation has been to compare two different funding strategies of the model; 1) where Bridge finance research projects themselves (and obtain revenues from the projects) and 2) where research projects are financed by Bridge industry partners (where Bridge will obtain no revenues). The simulations show that both funding strategies have their advantages. Advantages of the first funding strategy are that there is no limit to the amount of return of investment, and that Bridge will have full ownership of their research projects. Advantages of the second funding strategy are that Bridge will obtain stronger guarantees for funding, and that the organization does not have to depend on a large return of investment.

However, the comparison points to the conclusion that the first funding strategy would be the better alternative of the two. The main reason for this is that if the return of investment is optimized it would generate a considerably larger amount of research projects as the second funding strategy would (the second funding strategy has a maximum peak level, contrary to the first funding strategy). Since the amount of research projects represents innovations, the first funding strategy gives the best support for the aim of Bridge.

An optimal scenario would be where Bridge uses the first funding strategy of the model and the research generates innovations that push the return of investment to the 1.4 quota.

The simulations show no absolute truths. Its results are highly dependant on how the model has been implemented in the simulation software. However, with valid assumptions, the simulations illustrate significant aspects of the model that should be considered when Bridge is put in actual use.

7.1 Future research

This chapter contains some short suggestions to further research that can help to project the Bridge organization into an even more realistic model. One of the largest factors that are left out of our model is Bridge's educational program and its students that are attached to it. It may be so that having a breeding ground for young promising researchers within Bridge can lead to more innovations and more effective research projects, and thus generate increased revenues. But to fully understand the impact of the educational program, further research on the subject is needed.

All of the factors that were mentioned in the "Model limitations" chapter would benefit from more research. However, it is not reasonable to think that one can fully understand all of the underlying and indirect factors and how these interact in reality. A way of gaining more insight on the Bridge model and its components' interactions, would be to make an evaluation of the model some time after it has been put in use. Such an evaluation would have access to concrete numbers which would make it possible to make further operationalizations.

The model that we have created generates revenues in two ways; from research project revenues or from the industry that contributes with money to the research projects that they are involved in. In reality, both of these funding strategies could probably be used at the same time; one option doesn't have to limit the other. It is possible that a combination of both funding strategies could be the best solution, and therefore further research is needed.

References

Figures

"An example of how the Bridge organization and its members could look like", The Bridge Organization, Bridge model, 2009

"The five stages of the CWA framework", The Cognitive Engineering Laboratory, http://cel.mie.utoronto.ca/research/frameworks/cwa.htm, cited 3/3-2009

"The selection progress of research projects", The Bridge Organization, Bridge model 2009

"The three cornerstones of the "knowledge triangle"". The Bridge Organization, Bridge model, 2009

Literature

Arundel, Kanerva & Bordoy, Final results of the ASTP Survey for Fiscal Year 2007, UNU-MERIT 2008

Bray & Lee, University revenues from technology transfer: Licensing fees vs. equity positions, available at http://www.sciencedirect.com, cited 26/5-2009

EIT, KICs call, available at http://eit.europa.eu/kics-call.html, 2009

Gustafsson, Lanshammar & Sandblad, System och Modell – en introduktion till systemanalysen, Studentlitteratur 1982.

Kimball and Digenti, Leading Virtual Teams that Learn, Learning Mastery Press 2001

The Bridge Organization, Bridge model, 2009

Vicente, Kim J, Cognitive Work Analysis, Lawrence Erlbaum Associates Inc 1999

VOSTER consortium, Guidelines for Virtual Organizations, VTT Technical Research Center of Finland, Espoo 2004

Interviews

Beatus, Paul, Bridge project manager, Stockholm Science City, Stockholm, Sweden, 090318

Appendix 1: Underlying formulas for the model components

Members
AvailableAcademic + AvailableIndustry + (ResearchProjects * MembersPerProject)

KLO
Members / MembersPerKLO

BaseFunding
(InitialAcademic + InitialIndustry) * Admincost +
(InitialAcademic + InitialIndustry) * (KLOcost / MembersPerKLO) +
(InitialAcademic + InitialIndustry) * (TeamsFromBaseFunding% / 100) * ResearchCost +
(InitialAcademic + InitialIndustry) * (TeamsFromBaseFunding% / 100) * TravelCost

IndustryFunding
ResearchProjects * MembersPerProject * (ResearchCost + TravelCost) * IndustryContribution

AvaAcaGrowth
ProjectsDecrease * MembersPerProject * 0.5 +
(Funding * MemberProjectDistribution * 0.5) / (AdminCost + (KLOcost / MembersPerKLO))

AvaAcaDecrease
ProjectsGrowth * MembersPerProject * 0.5 +
AvailableAcademic * (MembersDecrease% / 100)

AvaIndGrowth
ProjectsDecrease * MembersPerProject * 0.5 +
(Funding * MemberProjectDistribution * 0.5) / (AdminCost + (KLOcost / MembersPerKLO))

AvaIndDecrease
ProjectsGrowth * MembersPerProject * 0.5 +
AvailableIndustry * (MembersDecrease% / 100)

ProjectsGrowth
(Efficiency% / 100) * (min (list (AvailableAcademic + AvailableIndustry)
(((Funding * (1 - MemberProjectDistribution))) / (TravelCost + ResearchCost)))) / MembersPerProject

ProjectsDecrease
ResearchProjects * (1 / Decay)

FundingGrowth
IndustryFee * (AvailableIndustry + (0.5 * ResearchProjects * MembersPerProject)) + BaseFunding + IndustryFunding + AccumulatedRevenues

FundingDecrease
KLOs * KLOcost +
AdminCost * Members +
TravelCost * ResearchProjects * MembersPerProject +
ResearchCost * ResearchProjects * MembersPerProject

AccRevGrowth
(1 / (1 + (e ^ ((- ticks) + (8))))) * (ResearchCost + TravelCost) * ResearchProjects * MembersPerProject * (ROI% / 100)

AccRevDecrease
AccumulatedRevenues * (1 / PatentYears)

Appendix 2: Survey on researchers

Question 1: How large are the average lab costs for a researcher per year?
Helena Karlström, Karolinska institutet: 500 000 SEK

Ola Hermansson, Karolinska institutet: 150 000 - 200 000 SEK

Simon Andras, Karolinska institutet: 150 000 SEK

Håkan Engquist, Uppsala universitet: 200 000 SEK

Pedro L. Granja, Instituto de Engenharia Biomédica: 20 000 - 30 000 €

Roel Kuijer, Universitar Medisch Centrum Groningen: The foundation of technical sciences grants standard bench fees of €17000 per year per person (100% employed). Our univeristy grants €9000 per year for bursary PhD students. So, it differs.

Question 2: Roughly, how many collaborations do you initiate with other researchers per year?

Helena Karlström, Karolinska institutet: 1-2

Ola Hermansson, Karolinska institutet: 5-10

Simon Andras, Karolinska institutet: 1

Håkan Engquist, Uppsala universitet: 3-5

Pedro L. Granja, Instituto de Engenharia Biomédica: 1-2

Roel Kuijer, Universitar Medisch Centrum Groningen: Many, roughly about 10

Question 3: How do these collaborations normally form?

Helena Karlström, Karolinska institutet: Conferences, internal meetings KI, scientific networks

Ola Hermansson, Karolinska institutet: 50-65 % …..????

Simon Andras, Karolinska institutet: After face to face meeting if the collaboration is unrelated to a specific grant call, or after grant calls that require collaborations, which usually involves extensive email and phone contacts.

Håkan Engquist, Uppsala universitet: Via networks

Pedro L. Granja, Instituto de Engenharia Biomédica: For me, the most important is knowing the collaborators. This way you can trust people and share your new ideas. In this sense you may adapt a given project to the work of someone that you admire and trust, and with whom you want to collaborate. As alternative, you may need a certain expertise to carry out an idea and then you may contact someone that you heard about, or that you met occasionally. Also, you may just start to collaborate because someone asked for your collaboration and you found it of interest. In my case, I prefer to build on establish collaborations than to create new ones. But since new ideas and possibilities are always appearing, many new collaborations are always formed. For instance, bride provided the opportunity for about 4-6 new collaborators, and many new project possibilities.

Roel Kuijer, Universitar Medisch Centrum Groningen: Discussions during meetings. Personal contacts.

Question 4: On a yearly basis, how many of your encounters with other researchers lead to actual collaborations?

Helena Karlström, Karolinska institutet: 1

Ola Hermansson, Karolinska institutet: If encounters mean intentional scientific discussions, around 20-25%. If it includes "bumping into" scientists for short talks at poster, presentations or after talks, 2-5%. If included all scientists I meet in a year, <<1%.

Simon Andras, Karolinska institutet: Unsure, but maybe less than 1 %

Håkan Engquist, Uppsala universitet: 2-3

Pedro L. Granja, Instituto de Engenharia Biomédica: 1-2

Roel Kuijer, Universitar Medisch Centrum Groningen: Not that many. Depend on grants! I'll be happy if we can grant one collaborative project per year.

Question 5: On the average, how long does a research-project usually last?

Helena Karlström, Karolinska institutet: 1-2 years

Ola Hermansson, Karolinska institutet: We have published small student projects in "small" journals, 3-6 months. Big serious projects last 6-10 years. I still haven't experienced an "average" project time, but it "should" theoretically be 4-5 years.

Simon Andras, Karolinska institutet: 2-3 years

Håkan Engquist, Uppsala universitet: 1-5, normally 3 years.

Pedro L. Granja, Instituto de Engenharia Biomédica: 3 years is the basis for any research project. If it works you do everything to extend it.

Roel Kuijer, Universitar Medisch Centrum Groningen: PhD projects last for 4 years. Postdoc varies between 1 and 3 years.

Question 6: How many research projects is it feasible to run simultaneously in your lab?

Helena Karlström, Karolinska institutet: 2 per person

Ola Hermansson, Karolinska institutet: 20-40

Simon Andras, Karolinska institutet: 4-6

Håkan Engquist, Uppsala universitet: 10

Pedro L. Granja, Instituto de Engenharia Biomédica: I am currently running 4 different funded projects and have applied to 6 new projects. Presently, I supervise 11 students and post docs, including some working on new ideas, not yet funded by any project. So, I would say I am currently running 8 different projects. In the whole lab, many more projects are run by other PIs. I believe a senior researcher can easily run 3 different projects simultaneously (depending on their magnitude, of course). More than that becomes really difficult.

Roel Kuijer, Universitar Medisch Centrum Groningen: I can manage 4-6 projects simultaniously. Our lab has 2 staff members. If they also manages 6 projects, the two of us then manage 8-12 projects.

Question 7: What is the limiting factor for starting more projects?

Helena Karlström, Karolinska institutet: Economy and resources

Ola Hermansson, Karolinska institutet: Funding to the extent that one can hire and fund 8-10 researchers, but the quality of project ideas and strategies go down with bigger labs (>12-15 people), so the limiting factor beyond a funding of 10 MSEK/year (incl salaries) then becomes good and well-trained people that can develop their projects more independently.

Simon Andras, Karolinska institutet: In my case, funding

Håkan Engquist, Uppsala universitet: Senior researchers

Pedro L. Granja, Instituto de Engenharia Biomédica: The limiting factor is the availability (time) to seriously manage the team and developments, considering that each project means a different topic.

Roel Kuijer, Universitar Medisch Centrum Groningen: Money!

Question 8: What are your thoughts about the KLO?

Helena Karlström, Karolinska institutet: N/a

Ola Hermansson, Karolinska institutet: N/a

Simon Andras, Karolinska institutet: N/a

Håkan Engquist, Uppsala universitet: Limited but very important to get working on a longer basis. Keeping the network alive is very important.

Pedro L. Granja, Instituto de Engenharia Biomédica: I see the KLO extremely useful for someone looking for industrial collaborations. When a scientist looks for scientific collaborations, he probably knows better than the KLO how, and with whom, to establish collaborations. But for translational research the KLO would undoubtedly be of value, since most scientists don't have those networks. The KLO may also encourage researchers to value their results and try to transform them into products.

Roel Kuijer, Universitar Medisch Centrum Groningen: The KLO can bring people together. Whether that will result in collaborations depends on the interaction between the individuals. Therefor personal contact is important. It is difficult to express the value of a KLO will highly depend on the individual.

Appendix 3: Danish universities and TTOs' statistics

Number of disclosures 2007
Aalborg University: 62
Aarhus University: 70
Technical University of Danmark: 77
IT-University of Copenhagen: 1
University of Copenhagen: 72
Roskilde University: 0
University of Southern Denmark: 21

Number of patents 2007
Aalborg University: 1
Aarhus University: 1
Technical University of Danmark: 6
IT-University of Copenhagen: 0
University of Copenhagen: 0
Roskilde University: 0
University of Southern Denmark: 0

Number of Start-ups in 2007
Aalborg University: 1
Aarhus University: 2
Technical University of Danmark: 3
IT-University of Copenhagen: 0
University of Copenhagen: 1
Roskilde University: 0
University of Southern Denmark: 1

Revenues (salaries excluded)
Aalborg University: N/a
Aarhus University: -Dkr 2 612 000
Technical University of Danmark: -Dkr 619 000
IT-University of Copenhagen: Dkr 589 000
University of Copenhagen: Dkr 1 756 000
Roskilde University: N/a
University of Southern Denmark: N/a

Number of faculties
Aalborg University: 3
Aarhus University: 7
Technical University of Danmark: 18
IT-University of Copenhagen: 2
University of Copenhagen: 8
Roskilde University: 6
University of Southern Denmark: 5

Number of scientists/researchers

Aalborg University: N/a
Aarhus University: 2826
Technical University of Danmark: 2500
IT-University of Copenhagen: 50 to 100
University of Copenhagen: 4700
Roskilde University: N/a
University of Southern Denmark: N/a

Research budget at the University

Aalborg University: N/a
Aarhus University: Dkr 939 000 000
Technical University of Danmark: Dkr 1 033 000 000
IT-University of Copenhagen: Dkr 65 000 000
University of Copenhagen: Dkr 2 700 000 000
Roskilde University: N/a
University of Southern Denmark: N/a

TTO results

Aalborg University: N/a
Aarhus University: -0,28%
Technical University of Danmark: -0,06%
IT-University of Copenhagen: 0,91%
University of Copenhagen: 0,07%
Roskilde University: N/a
University of Southern Denmark: N/a