Modeling the Integration of Global Talent and the current University-Industry collaboration in Norway:

Depicting and simulating current problems to evaluate possible solutions.

Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Philosophy in System Dynamics

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Acknowledge:

I personally would like to share an anecdote of my transition from being a student to my first professional job in Norway. It turns out that when I was living in Trondheim and taking my engineering degree at NTNU, I faced what I describe as my "black summer" in 2010. My father was supporting and financing my studies providing me the monetary requirement that the Norwegian government ask to non-European students to be granted a study permit. When I was just about to renew my study permit to fulfill my last academic year in summer 2010, I received a call from my family telling me that we got some financial problem due to a familiar issue. My career was about to end for an unsurprising event of life and there was no way my father or I could get a loan or scholarship to continuing my education. I remember I was shocked and frustrated, but I still had 2 months before my visa permit expired.

I called the black summer not only because my education in Norway was about to end, but also because I faced several personal problems including fighting to adapt myself to a new culture, I wished to take a Norwegian language curse at the university but PhD and exchange students were at the top of the priority list at NTNU to get a free Norwegian language course, and for me affording about 4500 NOK per month in a private school was not possible; Norwegian language was an important factor to get a part-time job as waiter or even cleaning staff and I was very disappointed with the university facilities for international students.

After all familiar and personal issues , I remember writing to the university facilities and several professor to let them know about my financial problem and asking for help, unfortunately I did not received any help from the university neither from the professor that I thought they could rise their hand and help me. My last chance was contacting a professor that I was introduced when I was recently admitted at NTNU introducing some project's ideas, his name will be always mean a lot for me in Norway: Tonni Franke J. who replied my email after several days with a summer job proposal. It was the ideal job, full time having half of the money required by UDI to continuing my education and earning work experience within my professional field. In the critical moment of my anecdote and after the new of a summer job opportunity for me, most of my ideas suggested in this master thesis for solving the unemployment among graduate international student, the need of labor force, the lack of languages curses for foreign students, and the university own problem pop up.

In my necessity, I would wish to have a free language course, a grant to cover my living expenses, a part-time job, and a university that creates opportunities for students to get in contact with industry. I thought that if somebody would offer me to work halve time for free but in return that person would cover at least the money I need to apply for my visa I would happily sing up a contract and start the immediately.

My adventure in Norway started from the moment I got my first summer job in Norway, then a Mexican restaurant hired me to work for them and I completed the money need to renew my visa, the job at the restaurant gave the opportunity of learning Norwegian despite the staff spoke either Spanish or English to me; Customers service was in Norwegian and my language skills started to improve. I learn a lot about how Norwegians interact and behave, and when I had my first professional job interview it was a piece of cake to answer to the human resources people

what they were willing to listing from me. The result was that just after the interview I was offered my current Job.

However, despite my story has a happy and lucky ending, I had the chance of meeting a lot of international students who felt alone in their adaptation process and that had a lot of difficulties getting a professional job and even though had to leave the country due to their perception of opportunities in Norway. Some of my still current and closest friends have had to take a second master program just to extend their job search period and to improve their skills to be more attractive to industry and still fighting, surviving and giving a change to Norway to used their knowledge, I could rise my hand for them; they are people with an average grater then B and that even speaks Norwegian.

I took my Master degree in system dynamics at UiB, because it allowed me as an engineer to get involved into the political and socio-economical fields, use my analytical skills to explore and model dynamics and their structure and finally suggest and justify solutions.

I dedicate this master thesis to all students that make my life in Norway amazing, because they were my main motivation to write about this fascinating topic and to show that Global Talent is willing to prove to Norway we could contribute a lot bring ideas obtained only by having the experience of living in a culture different than ours. We need to be seen as an investment.

I also want to acknowledge to Vanesa Armendariz for her support in the first semester of this master program, and her suggestions when editing the theoretical framework of this scientific paper. She has been of an incredible help. To my supervisor David W. who supported me by extending my time to deliver this thesis due to my own personal life. I know I am not the easiest and most extroversive student of your David, but I keep in mind many of your suggestion, classes and Ideas, I have always seen you as a great teacher.

To My sister Yolanda and her partner Eduardo: you have been of great support at home while writing this report. To my parent Liliana and Francisco: Many thanks for praying God to bless me, and to my little brother Luis who is soon graduating as MBA: thank you for sharing ideas of management of resources with me.

Abstract:

Despite the yearly increment on the population of international students [1], just about 46.8% of them take their first professional job in Norway after graduation. The above data neglects ERASMUS and exchange students. In addition, according the Norwegian labor and welfare department, about 50,000 foreigners were needed to supply Norway's need of high skilled labor force in 2012 [2, 3] and projections indicate this trend will remain [11]. Moreover, the university-industry collaboration has been linked to the transition of graduate international students to the Norwegian labor market and it seems that universities cannot easily meet the expectation and needs for both, private and public firms, in terms of high skilled workers [2, 8].

Among the reference literature some ideas and possible solutions can be found: 1) A statistical report about the integration of global talent in Norway suggests that one way to supply the need of high skilled labor force is by hiring Global Talent [2]. 2) Industry claims the university labors itself when bringing international students; University looks for its own interest [2, 3]. 3)The cooperation between University and Industry in Norway has been gradually increasing when it comes to R&D, but when it comes to teaching and specific program there is still to keep mutual university-industry agreements alive and stronger [8,22]. **Could the integration of GT to the Norwegian labor force crucial to activate the exponential growth of the expected university-Industry collaboration? How?**

A framework for depicting and simulating the transition of international graduate students to the Norwegian labor with special attention to the unemployment amount them, the huge demand of skilled worker in Norway, and University-industry collaboration has been successfully developed using stock and flow diagrams to show how the problem develops over time and what are the likely consequences of both the current structures and the suggested solutions.

The best results are achieved by combining all suggested ideas and turned into a combined policy: *"Industrial University Programs"*. The government, University, and industry could make the most of global talent while also solving their own needs; Norway could be ahead as Knowledge-based Economy. To prevent clogging from massive resistance to the Industrial University Programs:

- The cooperation, and role between university, industry must be very clear. University programs most not benefit all industrial needs, and the university should keep autonomous in the research line. Industry most support student taking program that already exist in the university curricula and that closely matches their need. Some combined programs can be designed in the case of CRIs.
- Enabling. We provide Industry with the labor it needs, but it most cooperate by supporting university's existing programs rather than trying to residing curricula. University will be provided with extra funds, but it should be also more selective when admitting new students to match the student's professional profile to industry need.
- Industrial Programs do not represent expenditure for the government in terms of funding, or taxation, or changing constitutional laws. We are creating a new monopoly called: Industrial Programs that is or becomes subject to Allied control between the government, industry and university.

Table of contents:

Chapter III: Testing the Model's Behavior

Chapter IV: Evaluating and Proposing Policies

Chapter V: Discussing Implementation

Chapter I:

The current dynamics and the Norwegian government's concerns

More often than we realize, systems cause their own crises, not external forces or individuals' mistakes [Peter Senge, The Fifth Discipline, 1994].

1. 1 Introduction to the Research Project

International students are attracted by almost all advance countries included Norway [1,2]. In this scientific paper, the "international students" term is used to refer students taking higher education with a foreign citizenship in Norway.

Despite the yearly increment on the population of international students [1], just about 46.8% of them take their first professional job in Norway after graduation. The above data neglects ERASMUS and exchange students. In addition, according the Norwegian labor and welfare department, about 50,000 foreigners were needed to supply Norway's need of high skilled labor force in 2012 [2, 3] and projections indicate this trend will remain [11]. Moreover, the university-industry collaboration has been linked to the transition of graduate international students to the Norwegian labor market and it seems that universities cannot easily meet the expectation and needs for both, private and public firms, in terms of high skilled workers [2, 8].

Our work focus on the Norwegian government's concerns: 1) the unemployment amount international graduate students, 2) the enormous demand on tertiary labor force in Norway, and 3) University-industry collaboration linked to the transition of graduate international students to the Norwegian labor market. It is important for the reader to have a good overview of the most used labels along this document; they are listed and explained next:

1. **Global Talent (GT):** Graduate International Students in Norway, i.e. students that has successfully completed their higher education program from a Norwegian institution with a foreign nationality.

2. **Foreign High Skilled Workers (FHSW):** High skilled workers coming to supply Norway's need of high educated manpower demand. This category does not include "Global Talent" because graduate international students are seen as the outcome of Norwegian Universities.

3. **Skilled Immigrants:** This includes both: Global Talent and Foreign High Skilled Workers.

4. **Norwegian High Skilled Workers (NHSW):** All Norwegian citizens who have completed higher education previously. This includes newly graduates and experienced workers.

Whereas the Global Talent's fraction getting a professional job after graduation has increased by a factor of three , see the right-side on figure 1, the population of foreign high skilled workers who has obtained their education outside Norway has risen by a factor of seven over the period 2003 to 2010 [1].
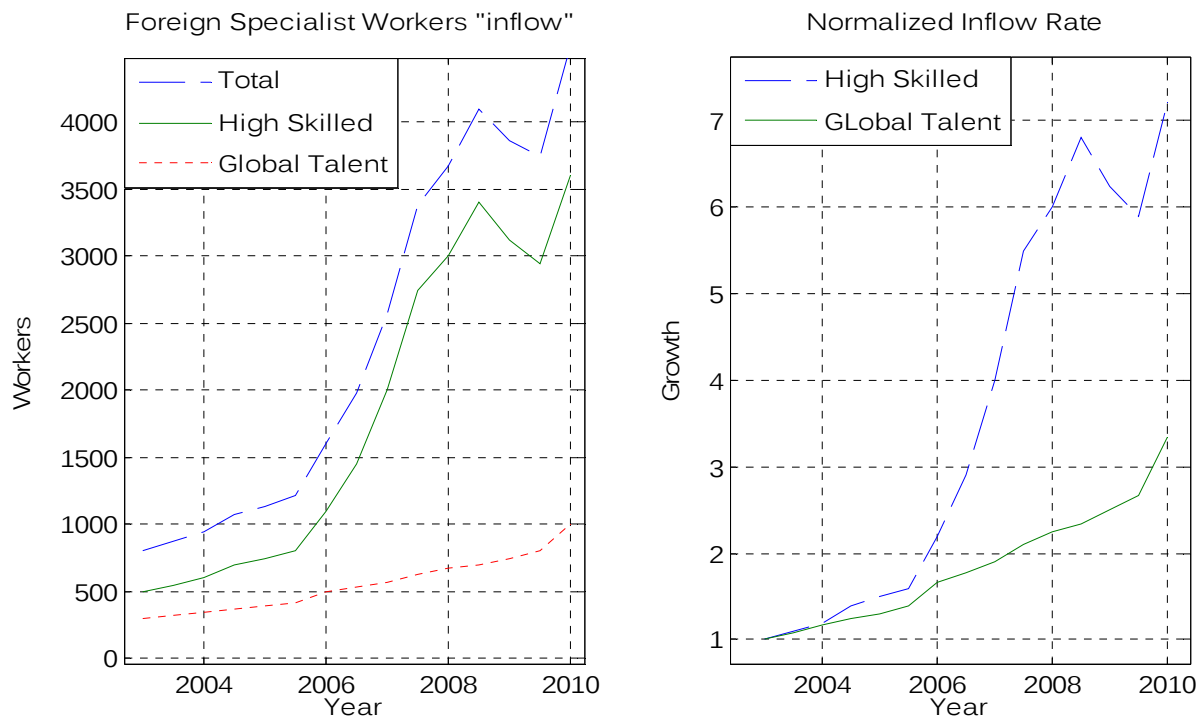
Figure 1: Inflow of Foreign high skilled workers. Those educated in Norway (Red) and outside Norway (Green). Source: DAMVAD STATISTICAL REPORT [1].

1.1.1 Motivation:

The main motivation of this research project is a belief that the university-industry collaboration can solve the unemployment among global talent and the need of skilled workers in the country. The some of the compelling reasons for this believe are: 1) the creation of industry-specific training programs and changing curricula according to employer´s technological development have been a crucial contribution of U.S. university to industrial innovation [9], and 2) another in favor is the creation industrial PhD program related to projects that combines academic research with innovation; which are coming as a great option for practical work or industrial experience [8, 22].

1.1.2 Research objective:

The aim of this master thesis is to develop a framework model for depicting and simulating not only the fluid transition of the international students in Norway from their admission to either emigration or employment process, but also the need of skilled labor force. Additionally we propone and develop a model to evaluate and reproduce empirical data about university-industry cross-cooperation. The system dynamic framework attempts to illustrate complex interplay between tangible relations of the university, industry and government, and the intangible aspect as the student's morale or perception of opportunities after graduation in Norway provoking the unemployment among them.

Our system dynamic model uses both, CLD (Cause and loop diagrams) and SFD (stock and flow models), to show how the problem develops over time and what are the likely consequences not only if no action is taken, but also the pros and coins of the suggested solutions.

1.1.3 Research question:

The specification of research questions strategy is an extremely important part of this master thesis; they influence the strategy that is employed in order to either provide answers to the questions or test hypotheses, some of them encoded in our reference literature.

1.1.3.1 Formulating the research questions:

The Norwegian Government concerns about the unemployment among international students not only because global talent spend years adapting to the host culture, but also because it represent a waste of money; Norway offers GT free education [2]. The Swedish government announced in 2011 that International students would be charged tuition at Swedish universities; this does not apply for EU-Residents [24, 25].

> **What could be the possible consequences of charging international students? Should Norway implement the Swedish strategy?**

A statistical report about the integration of global talent in Norway suggests that one way to supply the need of high skilled labor force is by hiring Global Talent [2].

> **Should the government force Industry to hire only GT?**

Industry claims the university labors itself when bringing international students; University looks for its own interest [2, 3].

> **Should the government control the admission of international students?**

We have discussed that the cooperation between University and Industry in Norway has been gradually increasing when it comes to R&D. Some teaching and specific programs are stronger or have better results than others. But when it comes to meet the third university-industry mission, there are still many things to do. Industrial PhDs are coming more popular in Norway [22]

> **Should the government stimulate industry and university to include GT as a third mission?**

> **Should the University and Industry reinforce their teaching by creating industrial programs for GT?**

> **Could the integration of GT to the Norwegian labor force be crucial to activate the growth of the expected university-Industry? How?**

1.2 Previous Research

1.2.1 Global Talent:

The Norwegian government hired a specialized Nordic socioeconomic and policy Consultant firm called DAMVAD to pick up statistical data. DAMVAD published 3 reports which are a valuable information source in this research. The reports proportionate different perspectives to the problematic seen by the Industry, Global Talent, and University. We retake the more interested points of view in this section.

Norway as first chose:

Most of the international student in Norway came primarily to study and about 70% of 1874 interviewed International students in Norway said that Norway was the first chose for studying abroad. 67% and 76% of 1770 international student from hard and soft sciences respectively chose Norway as first option to study.

There are five most popular factors that influenced international students' decision making to study in Norway, They are listened by ranking: English as education language, non-tuitions fees, Norway is a safe and secure country, possibility of a career upon graduation, and a degree from Norway will improve my career [2].

Decision making on staying in Norway:

Languages barriers, part-time job opportunities, industry and University facilities for international students are some factors that students discuss on DAMVAD's survey [2].

33% of active international student have a part time job, where 30% of those jobs are related to the students' professional field of study. 55% of the active student do not have a part-time job but are interested on one. Only 13% of the total active students do not want to get a part-time job.

A Part-time job may not only give to the international students the opportunity of help them with their living expenses but also to save money to be able to stay in Norway after graduation. If they are non-European students, in order to apply for a job seeking visa, i.e. allow to student to stay after graduation to look for a job, they must have sufficient funds for the period in which they intend to stay in Norway. This must correspond to 82% of salary grade 19 in the pay scale for Norwegian state employees. This currently corresponds to NOK 112,955 for six months, which amounts to NOK 18,826 per month [4].

The above may be an important factor for non-European students to either find a job as soon as possible before the student visa expires or to leave the country. 43% of the students coming to Norway would like to have professional job after graduation in the country, 25.9% said they would like to work in their home country, 24.1% would like to work in a country another country, while only 6.25 % do not know where to work [2].

A part-time job related to the students' study field, will also help to international student to compete in the industry, because according to the same report 2 in section 5.1, high skilled workers are employed by competence and experience.

The language barriers are by far the most important factor stated in the survey of DAMVAD report beside the cultural barriers and immigration rules.

Finally all active students who participated on the survey believe that the universities should do a better effort to guide them on the possibilities of getting a job. Unfortunately only 30% of them are satisfied with their host university's guidance for jobs.

Students who are in Norway:

Less than halve of the former students that participate on DAMVAD survey were currently leaving in Norway. From those still living in Norway, 75% are employed [2]. Form the latest report it seems to be that most of the international former students are hired by the public sector in jobs regarding teaching and healthcare [1]. About 40% of those who are currently unemployed and living in Norway have been employed at one point after graduation. The survey shows those more hard sciences former students are hired than those in soft science. PhD employment is higher than those with a master degree.

According to DAMVAD reports, it seems to be that the Norwegian language skill is not so relent when looking for a job. 73% of those who are employed declared to have a good command of the language compare to the 69% of the unemployed who answered the same. All graduated staying in Norway expressed to be satisfied with their Job in Norway.

Students who have left Norway:

Reasons to leave Norway after graduation	Pct	Number
No job opportunities	32	181
Wanted to return to my home country	26	147
Personal reasons	11	62
Job offer abroad	9	53
Bureaucracy	3	17
Other reasons	19	110
Total	**100**	**570**

Table 1: Reasons for leaving Norway [2]

DAMVAD reported that a large share of the international students leave the country, about 59% of those who are either master or bachelor , and about 42% of the PhD students, according to the survey [2]. There was not variation regarding the field of study on those who left and 78% of them have returned to home.

The main reason of those who left is that there are no Job opportunities. Table 1 is a copy of the results of DAMVAD survey in page 4 of the second report.

Finally 80% of those who left are employed in their home or another country. Most of them would consider returning to Norway to work or to work for a Norwegian company.

1.2.2 University-Industry cross-collaboration:

Some evidence exists on the effort of the Norwegian government to increase use of formal organizational structures for university-industry collaboration when it comes to R&D and innovation [8, 7]. Teaching university-industry collaboration has been linked to the transition of Global Talent to the Norwegian labor market and it seems that universities cannot easily meet the expectation and needs for both, private and public firms, in terms of high skilled workers [2, 8]. Norwegian universities have strategy documents of the important of a "third mission", another type of University-Industry collaboration; a third mission has not a clear definition but it is often defined as direct transfer of knowledge to society [8].

1.2.2.1 University-Industry: Research Interaction

The interaction between university and industry related for R&D may vary from an unpaid consultancy to expensive projects with short or long contracts [5]. The university-industry context has been facilitated by several structures and governmental policies that foment and support the formalization and institutionalization of collaborative relationships [7]. We classify the Norwegian government's most relevant policy instruments to speed cross-sector collaboration in two categories: 1) those for tax deduction, and 2) those for accessing to funding.

Figure 2 portrays a cause and loop diagram of how the two current programs influence research University-Industry collaboration. Cycle R1, is an example of an exponential growth which is the result of a positive or self-reinforced loop. A positive loop not only causes growth and amplifications, but also throws systems out of equilibrium [18]. C1 explains the constant industry collaboration growth to R&D and innovation over the last years; Industry access to money as they increases their cross-sector collaboration for R&D and innovation.

Cycles B1 and B2 are example of a goal seeking behavior also known as negative feedback which drives the system toward equilibrium, i.e. the system seeks a desired state or goal [18]. It is convenient for industry to increase R&D collaboration to reach the maximal amount of taxes that the government allows. D1 is an information delay which represents the gradual adjustment of perception [18], i.e. it takes time to evaluate whether there is or not an increment on the current R&D collaboration.
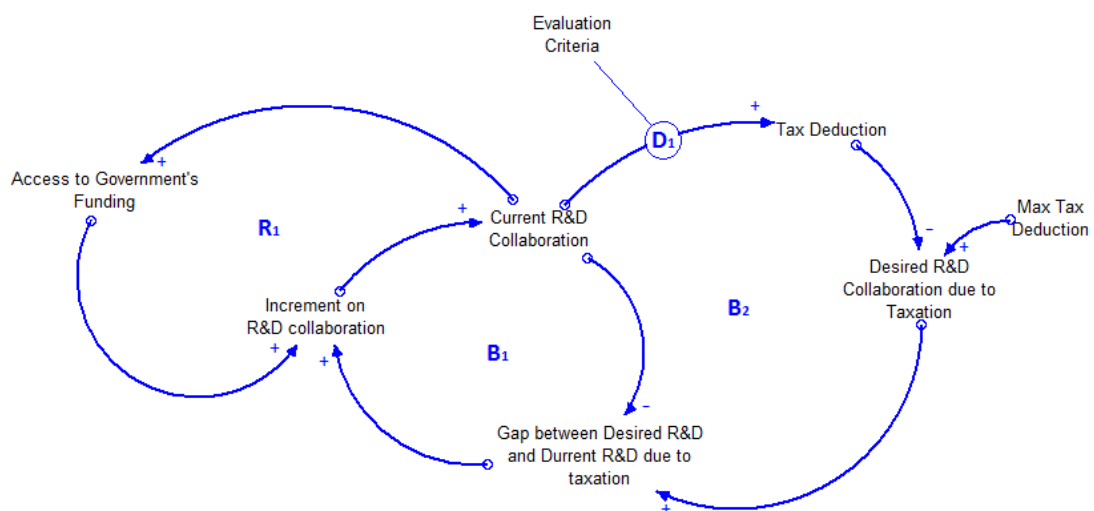

Figure 2: CLD diagram of the two types of programs for fomenting research collaboration

1.2.2.3 University-Industry: Teaching and specific training programs

Graduate students are the most important effect of universities on society, but Norway has still problems on integrating graduates global talent to the labor market. An interesting policy is suggested in the last DAMVAD's statistical report: Meeting the need of high skilled workers by integrating Global talent [1]. A parallel investigation about university-industry relations in Norway also emphasizes the importance of the transition of graduate students to work as result of the university-industry collaboration; the study exemplify that creating industry-specific training programs and changing curricula according to employer's technological developments have been the a crucial contribution of U.S. universities to industrial innovation. In Norway, it seems that some universities as NTNU have industry representatives in their board, but there are not specific agreements and investigation on it [8].

One of the most important dynamics over the last five years has been the (CRIs) institutionalization of Cooperative Research Centers [7], and the increment on the number of PhD in the industry [8], but we lack information about Master or Bachelor University-Industry specific degrees to support CRIs technological innovation, or CRIs' part-time jobs or scholarships for Global talent to increase their perception of opportunities and thus finally increase the fraction of those who become workers in Norway.

Figure 3 illustrates a cause and loop diagram on the current dynamics of CRI's as the closest teaching and specific training programs in Norway because they comprises industrial and specific PhD programs. On the diagram, As the CRI's increment, the need of high skilled workers also increments. The number of Needed High skilled workers not only accounts the technical staff, but also for all Industry PhD vacancies. The need of labor force is adjusted either by Norwegians, Potential Global talent, and High skilled workers coming from abroad. As the high skilled workers number increments in the country, both, university and industry increment on size. The University-Industry collaboration also depends on the industry and university size.

Note: There is not a mechanism to meet the proposed policy of DAMVAD, supply the need of labor force by hiring global talent.
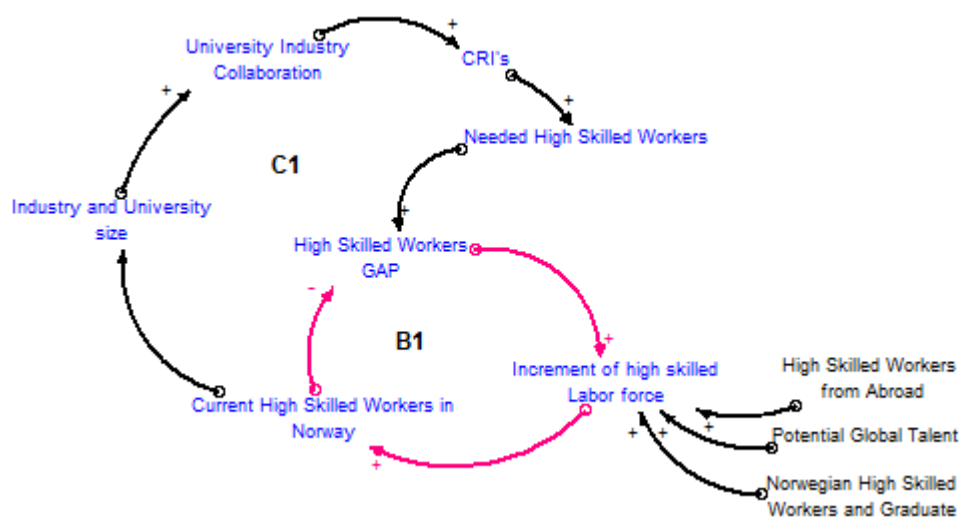

Figure 3: CLD Diagram of the CRI's Dynamics

1.2.2.3 University-Industry: The Third Mission

Patenting and the creation of Spin-off companies are used to evaluate amount of technology transfer to the society defined as third mission of university-industry collaboration. We take quick look at the role of the (TTOs) Technology Transfer Offices that since 2004 are the only paths for university's researchers to patent and commercialize technology [8]. Since 2004 the level of patent in Norway has remain flat over time indicating that this is not dynamically reacting to the government's effort to consolidate entrepreneurial universities. To understand the step back behavior on entrepreneurial universities, it is important to model the decision making of TTOs to whatever classify technology as proficient patent; the above because TTOs must ensure that only the most promising cases must be patented to save cost.

As discussed on Stersman's book [17] chapter 9, the diffusion and adoption of new technology or innovation often follows S-Shape growth behavior. S-Shape growths are the result of the interaction of a balancing and reinforcing loop, the positive feedback loop leads to an early exponential growth, but then after a delay, the balancing loop dominates the system and leads to goal seeking behavior [17, 18].

Figure 4 portrays a cause and loop diagram about the TTOs' adoption rate or decision rate. The adoption rate influences both: the performance of TTOs and the Researcher's desire on patenting. Whether TTOs' performance is good or not, it will decrease or increase the adoption rate of patents which also depend on the quantity of research intended to be commercialized. Later in section 2.3.3, we develop a stock and flow model of the TTO's performance.
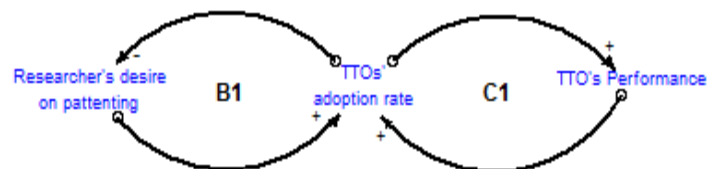

Figure 4: TTO's Decision Making on Patenting and commercialization of R&D

1.2.2.4 The University's needs:

There is not a quantitative data about how useful the universities services are to facilitate adaptation to international students, help the industry to find future employees, deal the students' immigration issues, etc. According to international university ranks, Norwegian Universities' Industrial income and Teaching have been scored as low over the last 3-4 years. By Industrial income is meant innovation programs and teaching is the evaluation of the learning environment [5, 6].

1.3 Statistics and Raw Data:

In this section data is plotted only for visualization and understanding some current dynamics. **Appendix A** contains the tables, sources, and calculation used to compute all graphs.

1.3.1 High Skilled Population in Norway:

As mentioned previously, in Norway, the number of high educated people has been increasing from 2003 to 2011. Figure 2 indicates that despite the population of Norwegian specialists population is larger than the internationals specialists' population; there are four times more International high skilled workers than in the past. The Norwegian high skilled labor population has also increased over a factor of 2.
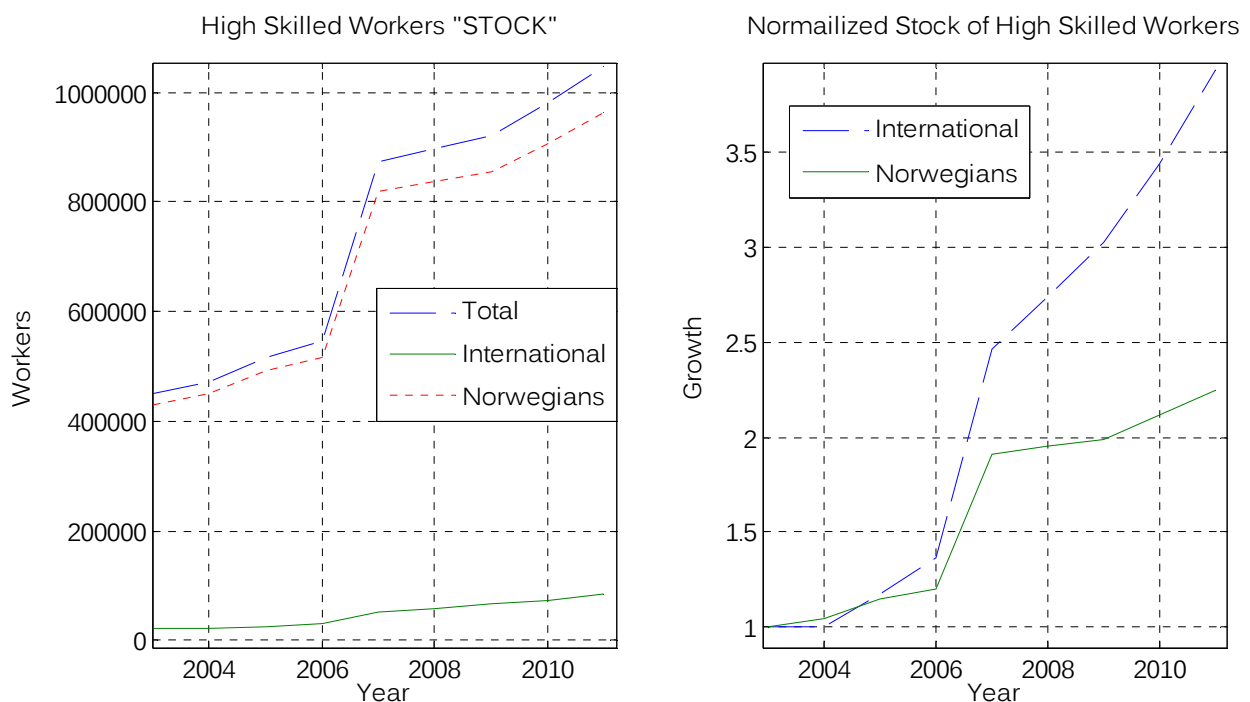

Figure 5: The Total Labor Force in Norway with Tertiary Education Level.

1.3.2 Jobs for Specialists in Norway:

Figure 6 portrays raw data on the annual job vacancies for people with tertiary education level. Both public and private industries are shown. The need of specialized manpower oscillates a bit more on the private than the public. The right side graph is a calculation of the growth on jobs taking the vacancies in 2006 as reference. This helps us to understand the labor market variation over the years.
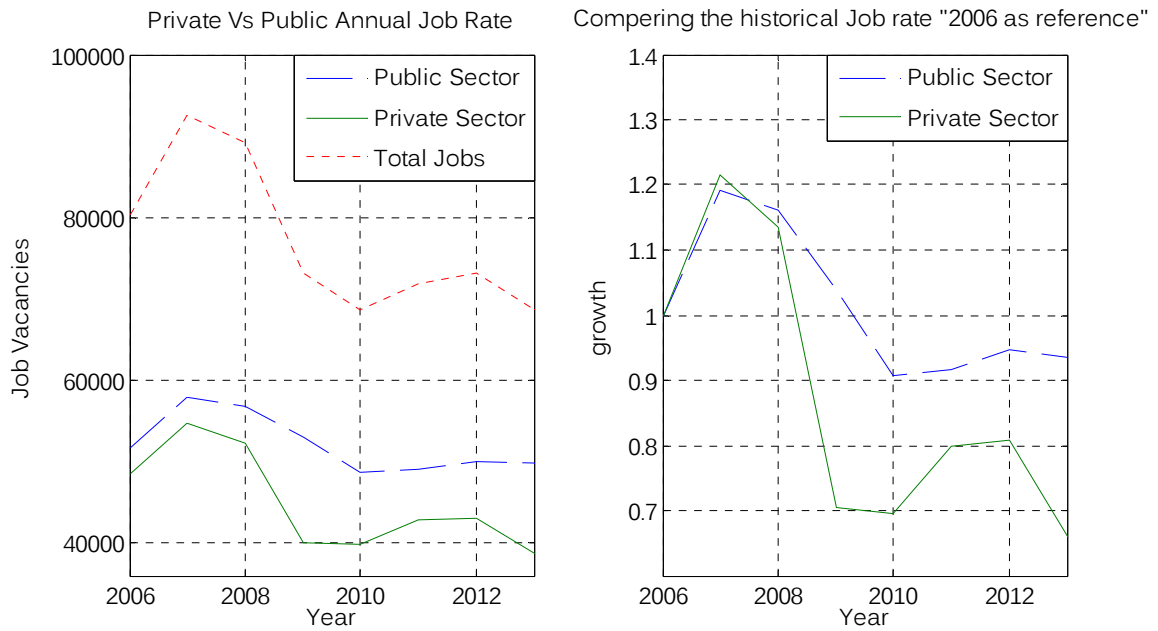
Figure 6: Job rate (Left); Normalized Job rate to data on 2006 (Right)

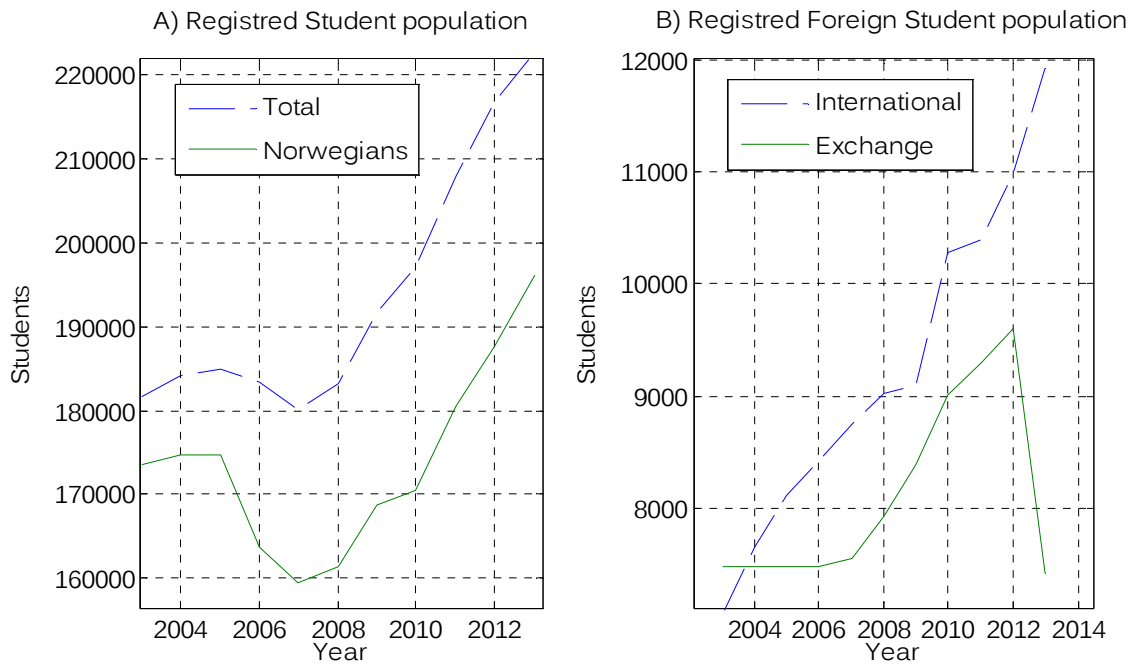### 1.3.3 Tertiary Students in Norway:

Figure 7: A) Stock of Registered Norwegian and TOTAL Students at all Norwegian universities and colleges. B) All registered international and Exchange students at Norwegian Universities and colleges.

In the introductory section, we have discussed that Norway as most advance countries are experiencing an increment not only on university students but also international students. In section 1.2, contains information that may explain this increment on international and exchange students in Norway. Figure 7 portrays the raw data (Stock) of the number of registered university students from 2003 to 2013. It represented a stock with only inflows since we need to compute how many of them have arrived and/or studied in Norway. Because the amount of Norwegian students and total students is very large compared to international and exchange students, we have used two plots 7.A and 7.B.

Additionally, figure 8.A) help us to visualize that beside the large number of Norwegian students, more and more international student are choosing Norway to take tertiary education than before. Finally 8.B) contains data on yearly graduation (flow), both Norwegian and international graduation rates behaves similar over time.
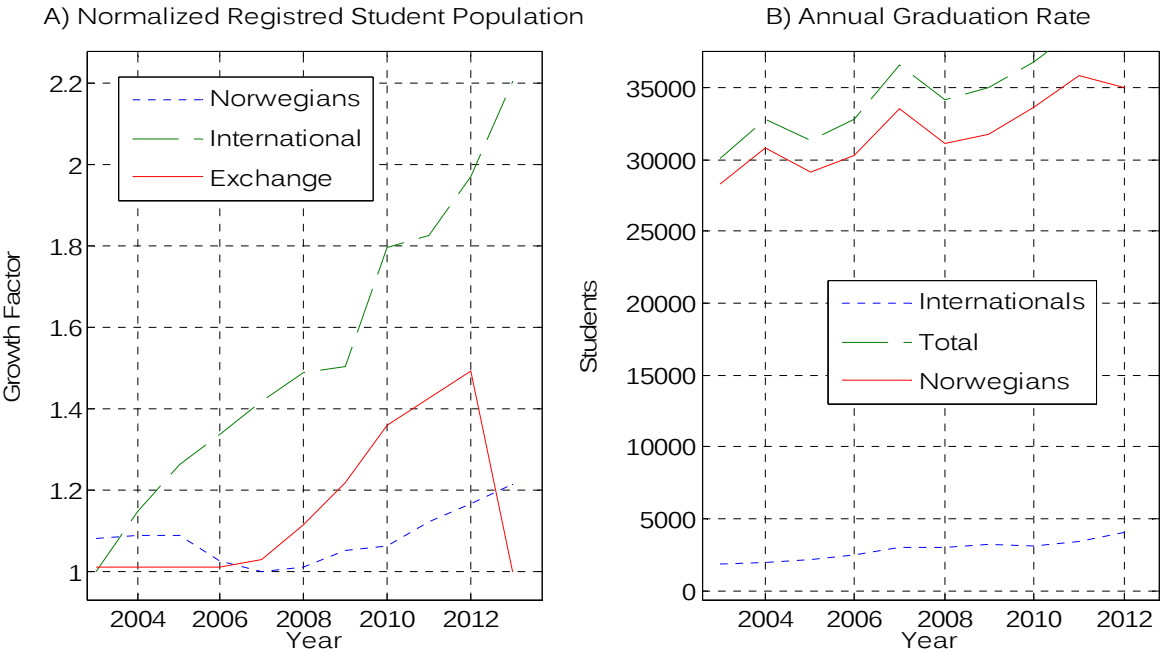

Figure 8: A) Normalized Stock of Registered Tertiary Students. B) Annual Graduation Rate

Chapter II

The Modeling Process

System dynamics models are normally implemented with stock and flow diagrams (SFD) to form computer-based models which allow us to simulate, test and predict not only the problematic behavior, but also policy implementations. In this Master Thesis research, models are implemented using iThink software from isee systems (http://www.iseesystems.com/).

System dynamics models are comprised of nonlinear differential equations, with separate equations for each bock in the model. Differential equations are resolved using numerical methods. IThink Software provides the first order Euler's method.

2.1 Modelling the GT population:

In section 1.1, the current dynamics of global talent was introduced. Figure 9 shows the key stock and flows to represent the population of M&B (Master and Bachelor) graduated students. The model's mathematical equations can be found in appendix A in detail.
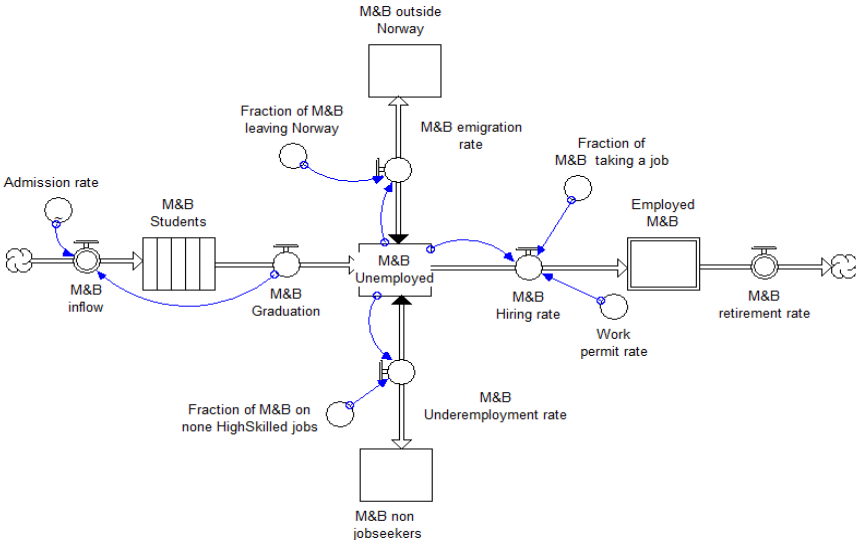

Figure 9: Modeling M&B population

The "M&B admission rate" determinates the number of Master and Bachelor students who are accepted to either a master or bachelor program. The length of International Master Programs in Norway is 2 years while the average time to complete a Bachelor is 3 years; therefore the "M&B Graduation rate" is the mean time to complete either a Bachelor or Master degree. After Graduation all students are considered unemployed, and because of the combination of different reasons such as: job opportunities, immigration policies, etc. Some of them will become employed, move abroad or non-jobseekers.

The emigration, hiring, and underemployment rate of M&B talent are represented as bi-flows, flows that can add or subtract to the stock, for instance statistical data indicates that some International graduate students have worked for one or more years but not all of them were register as formal employees in 2010, i.e. They become unemployed after one or two years of working.

2.1.1 The word-of-mouth model to estimate the M&B emigration rate:

The world of mouth is widely used in business models when predicting customer-to-customer communication about the characteristics of a product [16, 17]. Figure 10 portrays the stock and flow diagram of the word-of-mouth model.
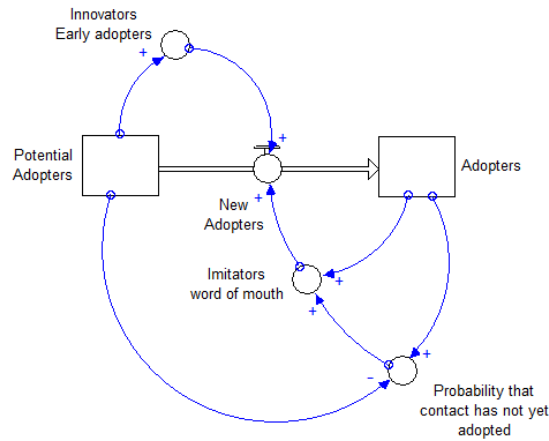
Figure 10: word-of-mouth model

The word-of-mouth model classifies customers in two categories: Innovators and Imitators. Innovators are customers who immediately are self-motivated to buy or adopt new ideas or products. Imitators, on the other hand, change their perception or decision on adopting new products or ideas by others customer's opinions or recommendation (word-of-mouth). The formulas are next shown:

1. $New\ adopters = Innovators + Imitators$
2. $Innovators = \rho * Potential\ Adopters$
3. $Imitators = \varphi * Adopters * Probability\ that\ contact\ has\ not\ yet\ adopted$
4. $Probability\ that\ contact\ has\ not\ yet\ adopted = \dfrac{Potential\ Adopters}{(Adopters + Potential\ Adopters)}$

Where $\rho + \varphi \neq 1$, $\gg \varphi$, and they are merely fractions.

Later, in section III, we model the student's perception of opportunities in Norway, in other words, what provoke that students feel attracted by Norway upon graduation. But from this point, we only focus on its causal effect on the emigration rate. Ideas and perceptions of opportunities are also spread word-by-word among the international students. See figure 11.
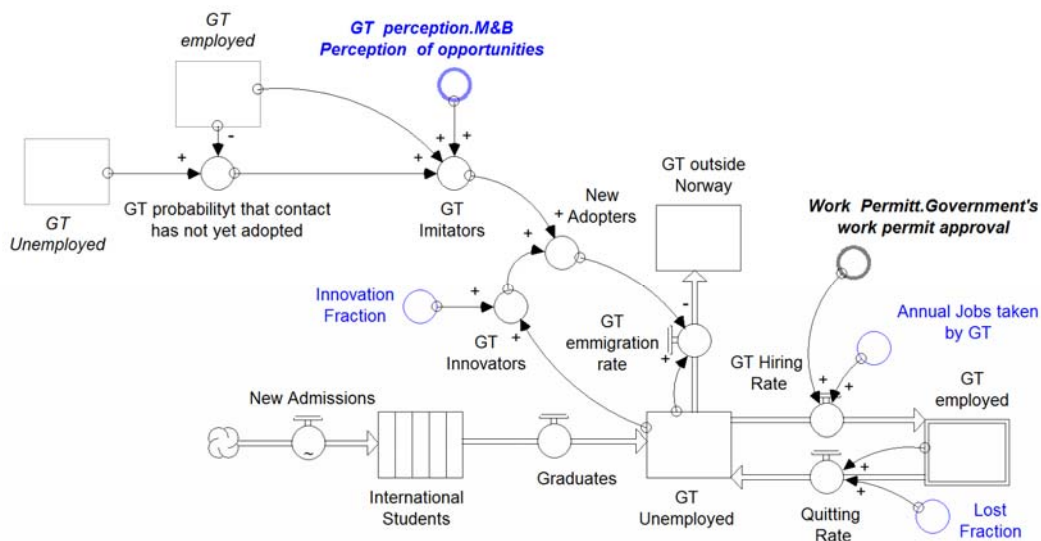

Figure 11: Word-of-mouth on perception of opportunities in Norway

GT emigration rate is the number of Global talent who decides to leave Norway each year. This parameter is yearly influenced by the perception of opportunities among international students that is spread word-of-mouth. We listed the models equation next:

1. $New\ adopters = Innovators + Imitators$
2. $Innovators =\ Innovation\ Fraction * GT\ Unemployed$
3. $Imitators =$
   $Perception\ of\ Opportunities * GT\ Employed *$
   $Probability\ that\ contact\ has\ not\ yet\ adopted$
4. $Probability\ that\ contact\ has\ not\ yet\ adopted = \frac{GT\ Unemployed}{(GT\ Employed + GT\ Unemployed)}$
5. $GT\ emmigration\ rate = GT\ Unemployed - New\ Adopters$

Adopters of opportunities are graduate international students who are employed yearly. While Graduates are consider as the potential customers in the model on figure 11 and 10 respectively. Finally GT emigrants are all unemployed GT minus the adopters of the idea that in Norway there are opportunities for Global Talent.

2.1.2 The Hiring Rate:

According to DAMVADS last report, there were 5333 Global Talents living in Norway which represent 60% of those who answer the interview. 5003 students said they had been employed at one point during their stay (1 or two years contract) while there were only 4196 Registered as formal employees.

1. $GT\ Hiring\ rate =\ GT\ unemployed * Fraction\ of\ GT\ employed$
2. $Fraction\ of\ GT\ employed = \frac{Registred\ Employed\ GT}{Total\ Employed\ GT} * Fraction\ of\ GT\ living\ in\ Norway$
3. $Fraction\ of\ GT\ employed\ = \frac{4196}{5003} * 0.60$

However, our task is modeling such fraction of formal employees and therefore we rearrange the model of figure 11 as the next: (Figure 12)
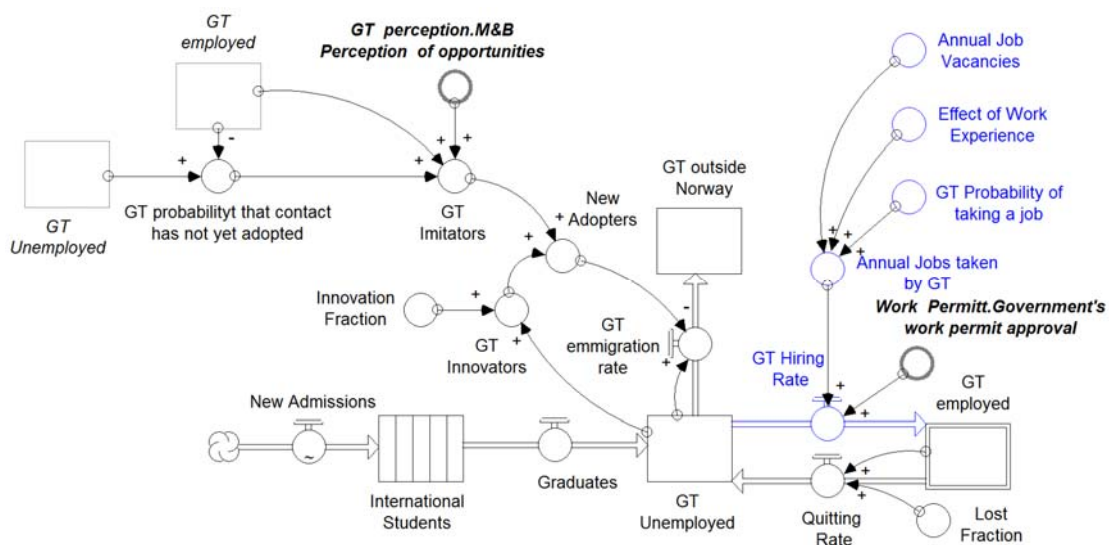

Figure 12: Modeling the GT hiring rate.

On figure 12, the hiring rate is basically the multiplication of the work permit approval times the modeled fraction of M&B taking a Job due to immigration rules. In addition, "Annual Jobs Taken by GT" is computed as the product of all job vacancies in Norway, the effect of having work experience, and the probability for Global talent to take a job in Norway. The dynamic of jobs vacancies can be observed in section 1.4 (figure 6).

1. $GT\ Hiring\ rate = Work\ permit\ approval * Annual\ Jobs\ taken\ by\ GT$
2. $Annual\ Jobs\ taken\ by\ GT = Total\ Jobs * M\&B\ probability\ of\ taking\ a\ Job *$
    $Effect\ of\ work\ experience$

Later in Section 2.4.5 the M&B probability of taking a Job will be formulated using exogenous data. Finally, PhDs are modelled on another similar structure, by knowing both: M&B and PhD the total global talent population can be estimated.
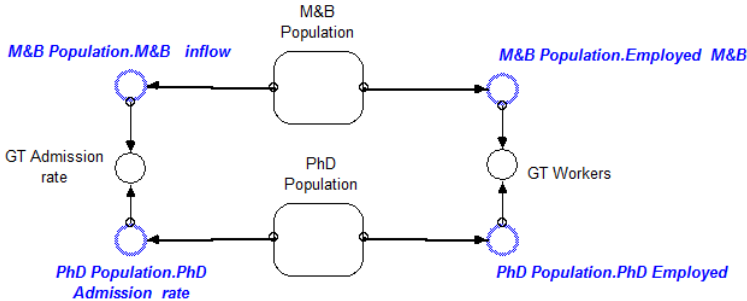

Figure 13: Total Global Talent population: Adding M&B and PhD.

2.2 Modeling the Skilled Labor Market:

2.2.1 Modeling the Government's work permit approval rate:

A gross increment on the number of High skilled workers coming to Norway has been emphasized previously while Global Talent has become part of the Norwegian labor market but in more moderate proportion. In Addition, some private companies claim to look for the candidates' competences whether they are inside or outside Norway, and there is not too much information regarding the governments strategic when approving the work permit for both: Global Talent and High skilled workers with a foreign degree. It seems that bringing foreign high skilled workers from abroad is not the faster option [4].

On the other hand, the main weakness for Global Talent is perhaps that Norwegian enterprise need work experience; when looking at some job search websites like: www.nav.no , www.finn.no/jobs , and www.jobbnorge.no. Several job position states: 1-3 years' work experiences preferably.

Figure 14 portrays the dynamics of Jobs for foreign high skilled workers and government's work-permit approval. When companies cannot find competences in Norway to cover their needs, they search for tertiary labor force abroad, and the government current immigration policies allows to companies to do it as far as there is a full-time job contract or job vacancy.

1. $Job\ for\ FHSW = Total\ Jobs - Norwegian\ Hiring\ rate - GT\ hiring\ rate$
2. $GT\ Hiring\ rate = GT\ Probability\ of\ taking\ a\ job * Total\ Jobs * Work\ Experience$
3. $Govermment's\ Work\ Permit\ Approval = \begin{cases} 1, & \frac{Jobs\ for\ FHSW + GT\ hiring\ rate}{Total\ Jobs} < 1 \\ 0, & else \end{cases}$
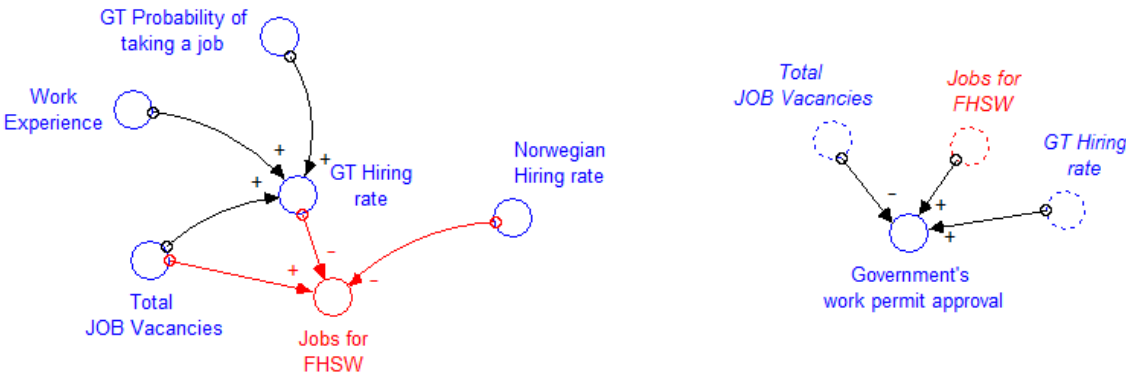

Figure 14: Jobs for Foreign High Skilled Workers and Government's work-permit approval

2.2.1 Total Labor Force dynamics:

Figure 15 portrays the dynamics of the current Norwegian tertiary manpower. Each year new students are accepted to higher education, as they successfully completed their education they may start looking for a job. The hiring rate on figure 15, is basically a fraction all potential Norwegian High-Skill workers. We could assume this is just as the total job vacancies due to extremely low unemployment rate in Norway, but some Norwegian graduates may take a gap year before really looking for a job.

- *Hiring rate =*
  Fraction of Potential Norwegian HSW getting a job ∗ *Potental Norwegian HSW*

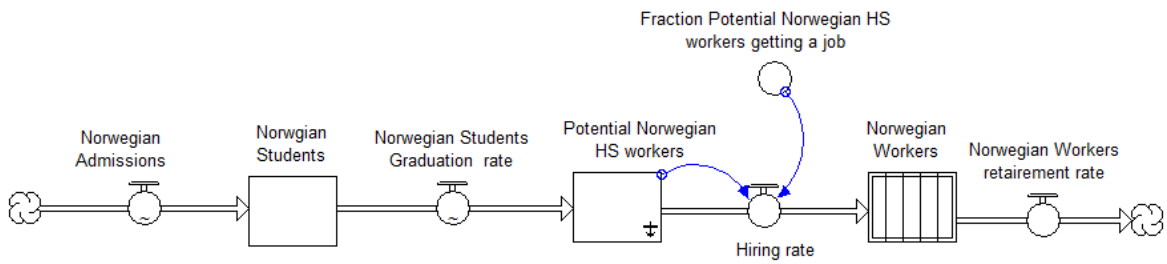**Figure 15: Norwegian High Skilled Workers Dynamics**

- *FHS workers hiring rate =*
  Work Permit approval ∗ *FHS probability of taking a job* ∗ *Jobs for FHSW*
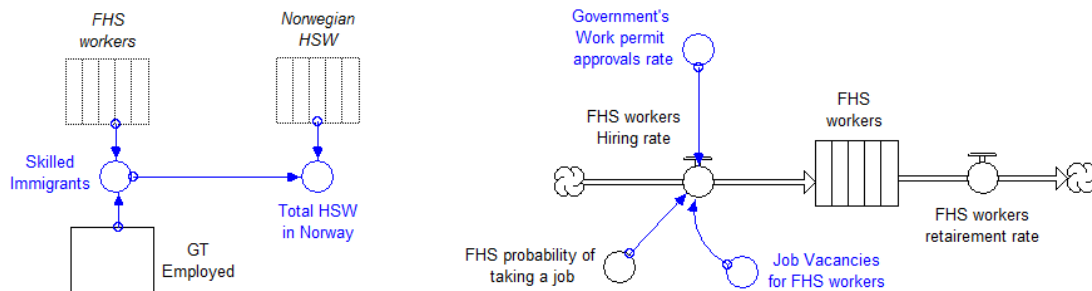

Figure 16: Foreign and Total Tertiary Labor Force

Figure 16 contains a stock and flow diagram to compute the total labor force. As mentioned previously, foreign high skilled workers can apply for jobs but they need to have a formal full-time job offer before applying for a work permit.

- *Skilled Immigrants = GT employed + FSH workers*

- *Total HSW in Norway = Skilled Immigrants + Norwegian HSW*

24

2.3 Modeling the University-Industry:

In section 1.3, three types of university collaboration are discussed: 1) R&D, 2) teaching and specific programs, 3) third mission. Some evidence exists on the effort of the Norwegian government to increase use of formal organizational structures for university-industry collaboration when it comes to R&D and innovation, in section 2.3.1; we model the current policy to foment the participation of private companies on R&D. Later in 2.3.2 and 2.3.3, we develop a SFD of the evolution of CRIs and the performance on TTOs.

2.3.1 R&D collaboration:

Referring section 1.3.2, the Norwegian government has played a key role fomenting cross-sector collaboration between university and industry. A relevant policy is the increment of Tax deduction which is as a Goal seeking behavior. Industry is willing to cooperate to deduct taxes; however the government establishes a limit or maximum percentage of the amount of tax to deduct. Figure 17 illustrates such dynamics using stocks and flows.
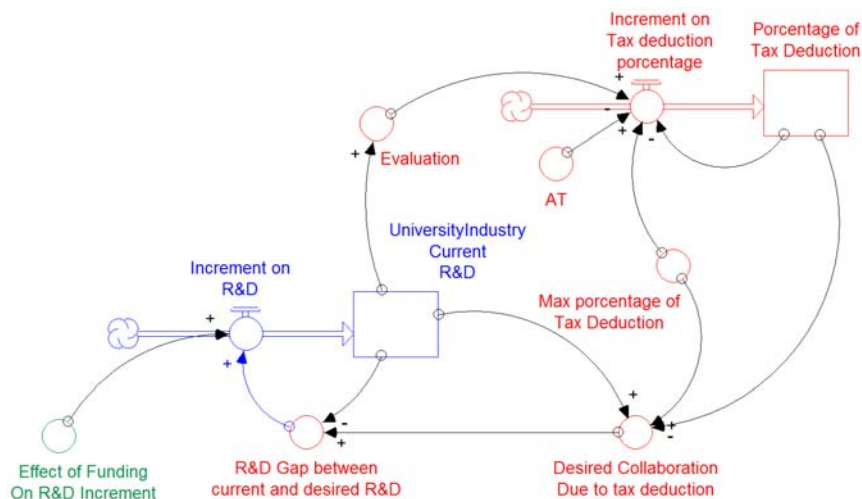

Figure 17: Fomenting University-Industry R&D collaboration

- $Increment\ on\ R\&D = R\&D\ Gap * Effect\ of\ Funding\ on\ R\&D\ Increment$
- $R\&D\ Gap = Desired\ Collaboration\ due\ to\ Tax\ deduction - Current\ R\&D$
- $Desired\ Collaboration\ due\ to\ tax\ deduction = \frac{\%\ of\ Tax\ deduction}{Max\ \%\ of\ Tax\ deduction} * Current\ R\&D$
- $Evaluation = \frac{Current\ R\&D - Delay(Current\ R\&D,1)}{Delay(Current\ R\&D,1)}$

$$Increment\ on\ Tax\ Deduction\ \% =$$
$$\begin{cases} 0 & Evaluation < 1 \\ \frac{Max\ Tax\ \% - \%\ Tax\ deduction}{AT}, & Evaluation \geq 0 \end{cases}$$

In addition to the Tax deduction strategy, the government launches calls for industry and university to access to public funding in order to research and develop new basic and applied Science. Initially the Industry is motivated to participate on these calls because the outcome could return a valuable profit. However, there is evidence that some of the current ongoing University-Industry consortiums (CRIs) lack the desired of continuing cooperation with their partners [5, 7]. Scientific literature argues the existence of a reinforcing loop on between the

industry interest on funding and cooperation, industrial profit, and Information and Knowledge or R&D [20].

In contrast to the tax deduction program, there is no limit to participate on the Government's calls for funding. Industry may participate due to its own convince and interests. But the interest of industry may vary if there is lack of profit or good management of the affined R&D project. This dynamics is portrayed on figure 18.
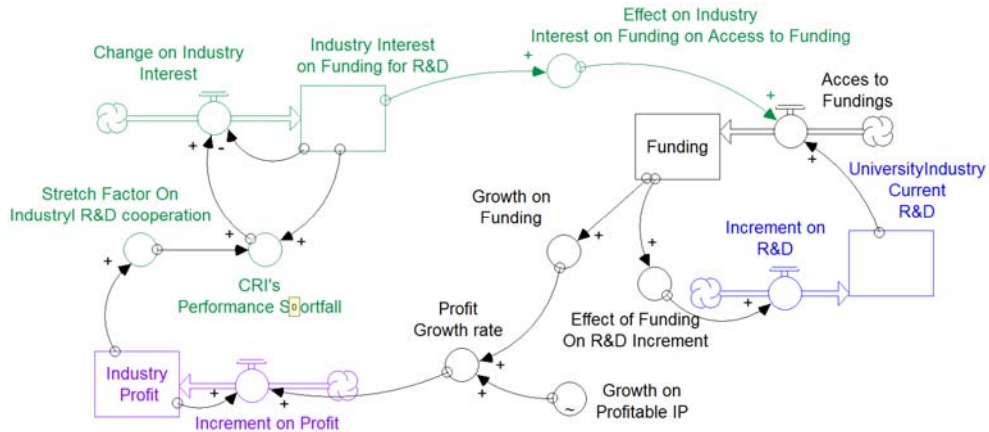

Figure 18: Fomenting University-Industry R&D collaboration

The green stock, flows, and converters, represent hill-climbing structure, see Chapter 13 on [17], mostly used when optimizing resources. We use the same analogy given in Sterman's book to understand Hill-climbing Structures: Imagine we are trying to climb a mountain on a foggy day and thus visibility is zero. We have no idea which path will lead us to the summit, and therefore, carefully take one step in each direction to see which way the grounds around you slopes, then we decide to climb based on our previous steps (Experience-Knowledge), i.e. the direction that most leads steeply up hill. In the same manner Industry-University consortiums may be unable to foresee both: the outcome of R&D cooperation, and the understanding with partners. Industry must carefully adapt their desire when cooperating.

- $Effect\ of\ Funding\ on\ R\&D\ Increment = \mathcal{F}(Industry\ Interest\ on\ funding)$
- $Change\ on\ Industry\ Interest = \dfrac{Industry\ Interest\ on\ funding - CRI'sPerformance\ Shortfall}{Avg\ Contract\ Time}$
- $CRI'sPerformance\ Shortfall =$
  $Industry\ Interest\ on\ funding * Stretch\ Factor\ on\ R\&D\ cooperation$
- $Stretch\ Factor\ on\ R\&D\ cooperation = Industr\ Profit^{\wedge Sensitivity\ to\ Profit}$

The purple stocks, flows, and converters, explain the Industry profit structure. The Profitable IP parameter will be discussed in detail in section 2.3.3, but for now, it measures the amount of patents or startup companies that university's TTO (Technology Transfer office) successfully have created and in reality generates profit. The parameter "Growth on obtained funding" is the increment on funding.

- $Increment\ on\ Industrial\ Profit = Industrial\ Profit * Profit\ Growth\ rate$
- $Profit\ Growth\ rate = Growth\ of\ Profitable\ IP + Growth\ on\ Funding$
- $Growth\ on\ Funding = \frac{Funding - delay(Funding,1)}{delay(Funding,1)}$

The more obtained public tender offers, the better a company's CV and thus the more funding for it. We model the increment of funding as the effect of the University-Industry current R&D. see the black colored Stock and flow on figure 18.

- $Increment\ on\ Funding = Current\ R\&D^{\wedge Sensitiviy\ of\ R\&D\ on\ Funding}$

In resume, Industry desire to optimize capital collaborating on research to reduce the amount of taxes to pay, but when reaching the tax deduction limit, or maximal percentage of tax deduction, there is no longer a stimulus to increase or strength collaboration unless the government change the taxation boundaries (Goal seeking behavior). By contrary, the access to public founds initiatives provoke a steady growth (Reinforcing loop); there is an opportunity to finance the R&D and keep the Industry technologically competitive for the market and constantly collaborating with the university. Figure 19 portrays the two discussed policies.
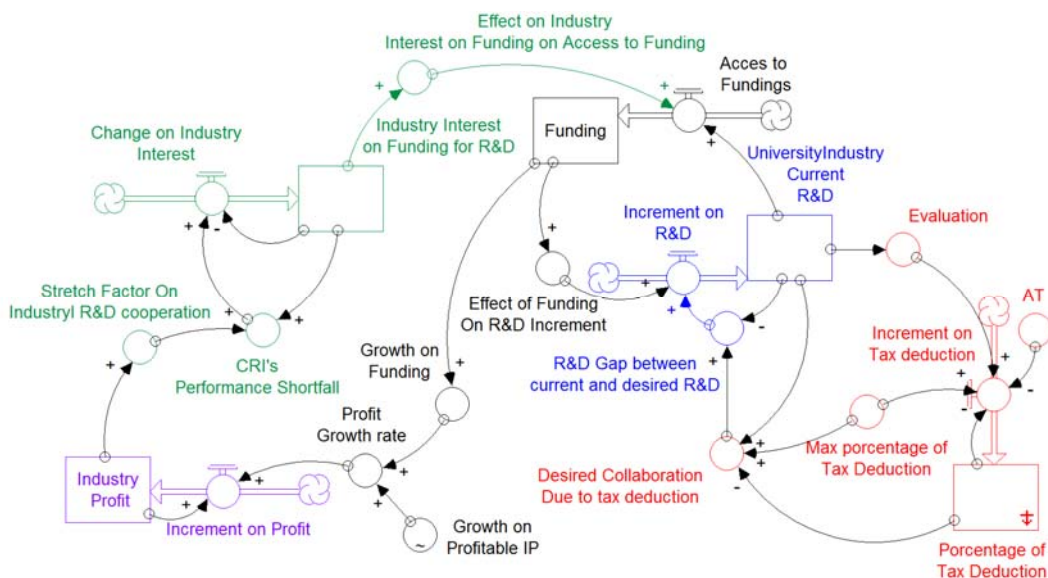

Figure 19: Fomenting University-Industry R&D collaboration

2.3.2 Teaching and Specific Training Programs:

Cooperative Research Centers CR's bring research job positions such: teaching, technical staff and specially PhD industrial programs; we therefore analyze the increment of CRIs in terms of employees to model teaching and specific training programs which is define as another type of cross-cooperation between the industry and university.

Figure 20 portrays a stock and flow model of the CRIs' growth dynamics. The industry increments R&D cooperation with university, therefore, the desired number of CRI's employees also increments.

- Desired number of CRIs employees = Step(UniversityIndustry_Current__R&D/100,1) * Annual__Job_Market_in_Norway

To compute the CRI employees' population, we recur to a goal seeking behavior model:

- $Hiring\ rate =$ Discrepancy in CRI workers =
  outflow_rate + ((Desired_number_of_CRI's_Employees − CRI's_employees)/
  Hiring_Process_Time)
- Outflow rate = CRI's_employees * Quit_Fraction

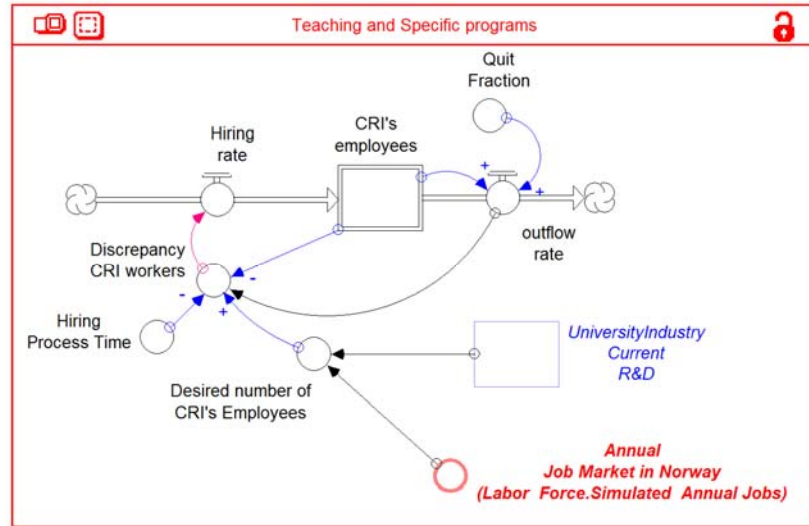The outflow rate is basically the number of employees deciding to quick or retires

Figure 20: CRI Dynamics

For further simulation and computation, it is convenient to split on 3 cohorts: Norwegian high skilled workers, foreign high skilled workers, and global talent. See figure 21.

$$Hiring\ rate = \frac{Discrepancy\ on\ CRIs'workers\ *\ (NHSW * W1 + FHSW * W2 + GT * W3)}{Hiring\ process\ time}$$

Where $W1 + W2 + W3 = 1$, and they represent the trust on Norwegian High skilled Workers (NHSW), Foreign High Skilled workers (FHSW) and Global Talent (GT) respectively.
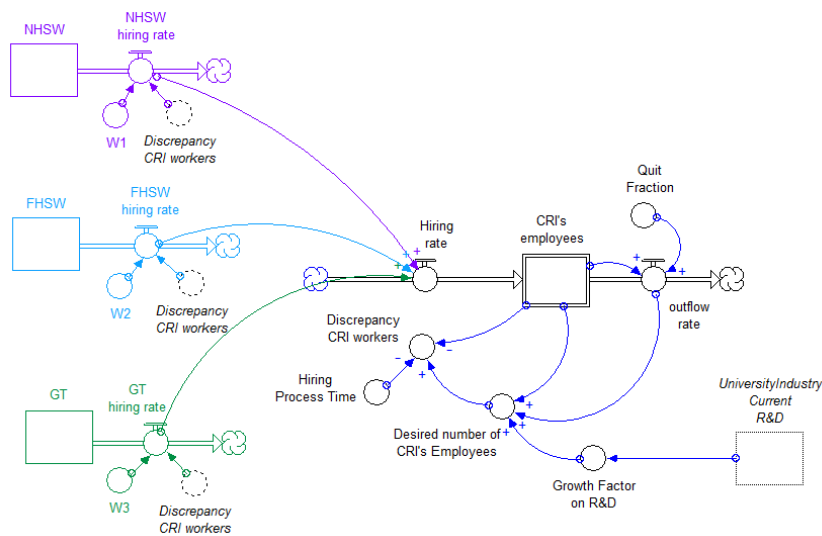

Figure 21: CRI Dynamics

2.3.3 Modelling the third mission:

In section 1.3.4, patenting and creation of Spin-off companies is used to evaluate amount of technology transfer to the society defined as third mission of university-industry collaboration. The TTOs are on charged of evaluating potential patents and commercialization of developed technology in any CRIs or University installations. TTOs must not only ensure that only the most promising cases are evaluated to generate profit, but also to optimize cost.

As the industry-University increases cooperation, i.e., CRIs creates information and knowledge, the third-mission is to sort out the amount of potential technology likely to be adopted by TTOs. Whether the decision of TTOs is good or not, the adopted technology will lead to two outcomes: Profitable technology or useless technology; TTOs cannot not guarantee a given technology or idea booms the market and generate profit, but TTOs' task is to optimize their own criteria when selecting what they believe it is a promising technology.

The spread of rumor, new ideas, and adoption of new technology can all be view as epidemic spreading. Sterman in chapter 9 [17] developed an innovation diffusion model from the principle of a SI epidemic model; SI stands for Susceptible and Infected people. In a similar manner, we used the SIRD epidemic model on figure 22 to model the university-Industry third mission [17, 19].
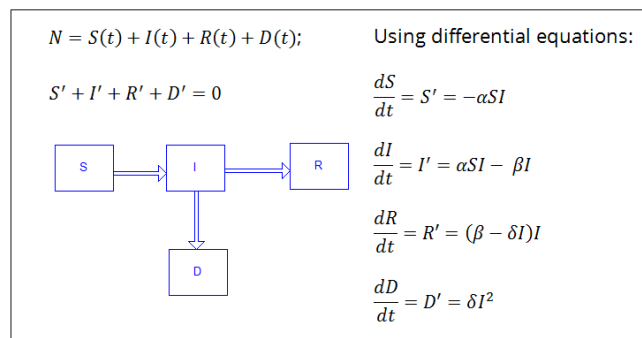

$$N = S(t) + I(t) + R(t) + D(t);$$

$$S' + I' + R' + D' = 0$$

Using differential equations:

$$\frac{dS}{dt} = S' = -\alpha SI$$

$$\frac{dI}{dt} = I' = \alpha SI - \beta I$$

$$\frac{dR}{dt} = R' = (\beta - \delta I)I$$

$$\frac{dD}{dt} = D' = \delta I^2$$

Figure 22: The SIRD Model

The SIRD model assumes that a susceptible population (S) is likely to be infected (I) only once. In addition, the infected population (I) may recover (R) or die (D). On Figure 21, α , β , and δ are the rate of infection, recovery, and removal respectively. Later on Figure 23, α , β , and δ are represented by W1, W2, W3 respectively due to iThink software's restriction on characters.
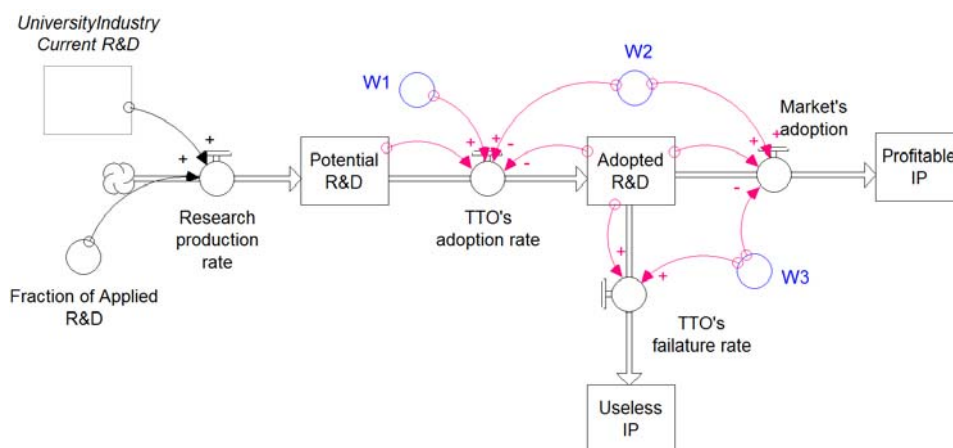

Figure 23: TTO's Decision making on Intellectual Property

Figure 23 portrays TTO's Decision making on Intellectual property. Making an analogy with the SIRD model, we next develop equations for the SFD on the figure 23.

- Research Production rate = UnivesityIndustry Current R&D*Fraction of Applied R&D
- TTO's adpotion rate = Potential R&D $*$ W1 $-$ W2 $*$ Adopted R&D
- Market's adpotion rate = (W2 $-$ W3 $*$ Adopted R&D) $*$ Adopted R&D
- TTO's failure rate = W3 $*$ Adopted R&D^2

The research production rate formula gives a fraction of the current university-industry R&D which will become potential to be evaluated by TTOs, this because R&D is usually fragmented in basic and applied. Applied R&D is market oriented technology while basic R&D only contributes to the scientific common knowledge [20].

We must next sort out what W1, W2, and W3 represent in our model (figure 23). W1 is the R&D review rate representing how often potential R&D is evaluated by TTO's committee. In addition, TTOs' dilemma is generating profit while also optimizing cost; in other words, the more patenting or spinning off does not necessarily means the more profit or success: it may also mean waste of effort, time and money if the patented idea is not well accepted by the market. TTO's success must not depend on the market but rather on selecting technology that solves the market's need.

W2 and W3 represent the TTO's pressure to generate profit and to optimize cost:

- $W2 = TTOs'pressure\ to\ generate\ profit = \frac{Profitable\ IP}{Adopted\ R\&D}$
- $W3 = TTOs'pressure\ to\ optimize\ cost = \frac{Useless\ IP}{Adopted\ R\&D}$
- $TTOs'pressure\ to\ optimize\ cost = 1 - W2 = 1 - TTOs'pressure\ to\ generate\ profit$
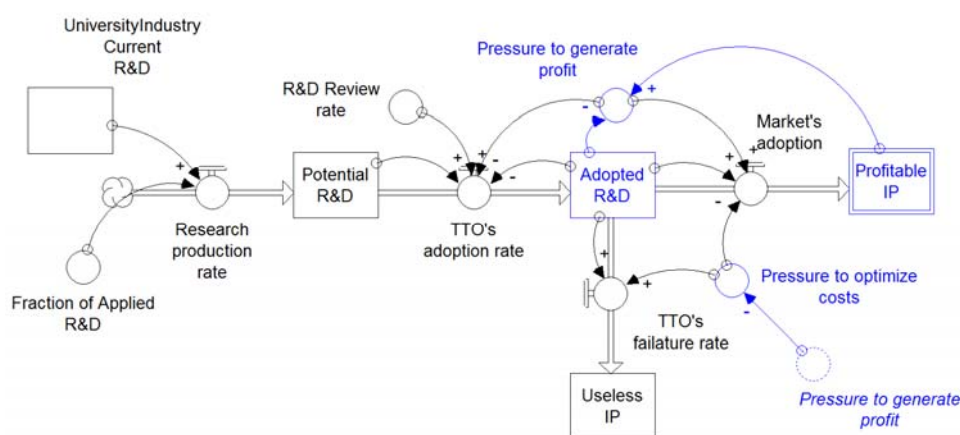

Figure 24 : TTO's Decision making on Intellectual Property

2.4 Modeling of exogenous parameters:

As discussed in Section 1.1, the Norwegian government's concern is the amount or fraction of Global Talent who decided to leave when Norway is in need of tertiary labor force, in other words and looking at figure 9 and 25, we are interested on finding what provokes the variable called: "Fraction of M&B leaving Norway".

The Government, by mean of DAMVAD, conducted a large statistic study and recollected several possible causes to the issue [1-3]. DAMVAD's statistical data is very useful but causal information to feed our SFD model of figure 25. The search for causes in often perceived to be superfluous and often social sciences merely describe the phenomena as the data recollected by DAMVAD. Causal thinking, on the other hand, it is well acceptable in health sciences for instance when researching, for causes of disease to find effective treatments. In this section we provide a theoretical framework, conditions, assumptions, and finally challenges for our approach to model **Causal Knowledge.** We strongly recommend reading **Appendix B.**
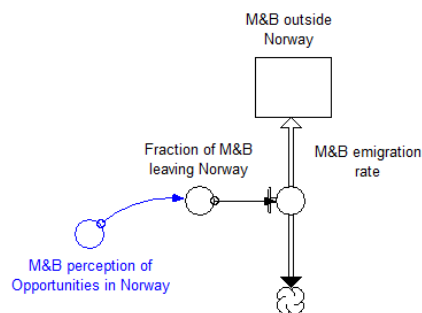

Figure 25: Effect of the Students Perceptions

2.4.1 Modeling GT perception of opportunities
Background Knowledge (Statistic data)

The perception of a group of international students is summarized below: (See section 5.2 of [2])

1. Students leaving in Norway are positive towards Norway
2. Expensive to live in Norway
3. Norway is difficult in terms of integration and job opportunities.
4. Norwegians are a bit difficult to get to know.
5. It is a stress factor that the work permit is only linked to the current Job. If they get break between jobs, they have to move out.
6. The working language is almost Norwegian, and the mentality in the industry is not very international.
7. Norwegian employers are not used to work with foreign employees. It is crucial for the students to be integrated in all areas and not only in the job.
8. They pointed out that it is very positive to have a part-time job while studying, because it helps to get quickly integrated and learn Norwegian.
9. They did not used help from the university to figure things, but they used help from Norwegians friends instead.

Conditional Structural Modelling of GT perception of opportunities: A theoretical framework and process:

Whilst it might seem uncontroversial in health sciences looking for causes, Causal perspective is less obvious in social sciences research, perhaps because it is apparently harder to glean general law in the social sciences than in other sciences, due to the probabilistic character of human behavior [12]. Our statistical language and analytical tools were design to study association and not causation. Causal thinking is mainly limited by the present of confounding bias, but in modern thinking on causal inference, many methods and algorithm are widely used to control confounding bias as they will be discussed later [12, 13]. We therefore focus all the attention to sort out under what condition structural models give us casual knowledge, and use the causal knowledge to build a structural model.

In order to gain causal knowledge, one most questioning: is a probabilistic characterization of causation a symptom of indeterministic causality or rather of our incomplete and uncertain knowledge? In physics, substantial issues arise about the possibility of indeterminist. Whether or not this concept exist, from the epidemiological point of view, a probabilistic characterization of causes on structural models only commits to state that our knowledge is limited and uncertain. Therefore we must struggle on reducing bias and confounding by modeling only stable relations consistent to our background knowledge. Structural modeling means that we do not aim at making metaphysical claims about causal relations, but rather at saying when we have enough reasons –specifically, reasons about our background knowledge and about structural stability – to believe that we hit upon a causal relation [12].

Using the background knowledge provided in section 1.2.1, Consider four variables: GT Perception of Opportunities (P), University facilities for international students (U), Financial mean (F), and Cultural Adaptation of International Students (C). In view of **Appendix B** and figure 26, isn't our example a structural approach? We are interested on the effect of C, U, and F on P.
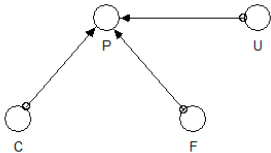

Figure 26: Causal Diagram: Perception of Opportunities

The above diagram is causal model, but in many circumstances the same effect can be produced by several causes, or the same cause can produce several effects. A confounding variable, or confounder, is a variable which is the common cause of the putative cause and the outcome of the same putative cause [12]. In other words, part-time Job (F) is influenced by (C) cultural adaptation, and consequently both influences (P) perception of opportunities. See the next figure:
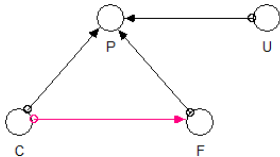

Figure 27: Exemplifying Confounder bias (Red line)

As discussed previously, disbelief comes from the idea of confounding bias present on structural modeling because it is difficult to control the effect of a confounder, i.e. any statistical relationship between two variables may be reversed by including additional factors in the analysis. Let's clarify the above using two examples:

1) We may find that the perception of opportunities is linked to the cultural adaption of the students, i.e. we found that the students who said being more integrated to the Norwegian society have better perception of opportunities in Norway finding a professional job after graduation. However, when adjusting for part-time work experience, there are less adapted students, than those who feel not integrated at all, working in Norway after graduation. Additional adjusting for Norwegian language skills, integrated students again seems more likely to get a professional job (opportunities) than those who are not integrated, and so on.

2) We may discover that European students are more likely to obtain a job after graduation than non-European students but, adjusting for part-time work opportunities, there are less EU students working in Norway than non-Europeans, additional adjusting for Norwegian Language skills, EU students again obtain better chances to work than those student who are not from Europe in every Norwegian Skill-Part time work experience group, and so on.

The above two example illustrate the difficulty and incredulity when formulating or stating causal relationships in the present of confounding bias. In next paragraphs we develop a causal structural model with many confounders unquestioning the background statistical data in section 1.2.1.

Analyzing the statistical data, it seems that students' perception on opportunities is related to the student's integration to the Norwegian culture (Cultural adaptation), financial means (part-time jobs), and the university facilities support. Having a part-time job might not only be important for the student's economical support, but also because some global talent considers a part-time job as a good chance to get to know Norwegians. Therefore, the effect of part-time jobs either to facilitate the cultural interaction with the host country or to increase the opportunities perception is modeled here. Moreover, another concern among global talent is the access to Norwegian language courses, some students consider important to speak the local language to facilitate their integration to Norway while others believe that it is crucial to speak Norwegian when looking for a part-time job. Therefore the effect of speaking Norwegian on both: cultural integration and part-time jobs are considered in the model on figure 28.
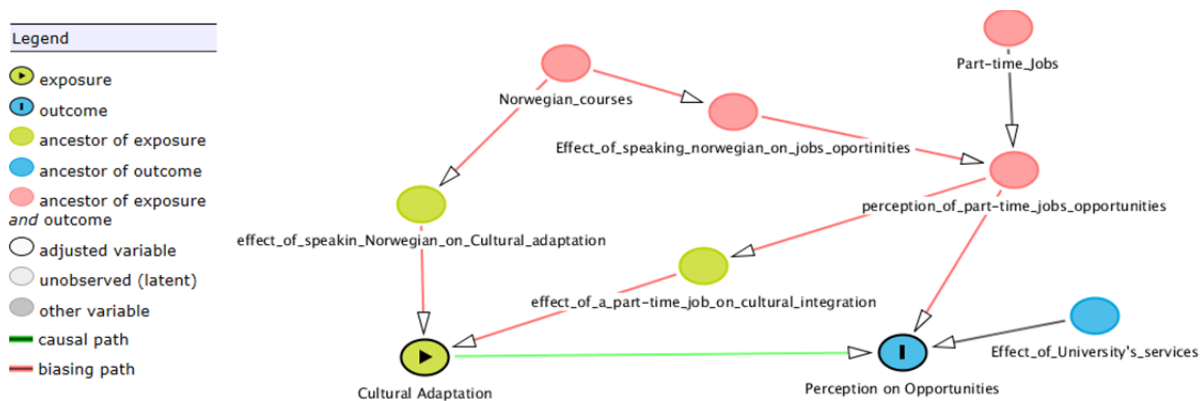
Figure 28: Casual Diagram: measuring the cultural adaptation effect on perception of opportunities given other variables

For future proposes in our entire Stock and flow model, It is not only important to estimate the cultural adaptation of the students because this is assumed to be the same perception of the human resources personnel when recruiting global talent, but also because it influences the decision of global talent to whether stay or not in Norway after graduation. By using the BACK-DOOR criterion (see appendix B) one is able to find biasing paths of cofounders and make clear under which assumption is valid to state that the Perception of opportunities is influenced by the cultural adaptation of the global talent. Referring figure 25 we need to sort out if the above statement is valid when adjusting (assumptions) to one or many cohorts of global talent, for instance: students who only take Norwegian courses, student that had both: Norwegian courses and Part-time Jobs, Students satisfied with the university facilities, etc.

Using online-free software: **http://www.dagitty.net**, we created figure 28 and found biasing paths. The software also gives us which assumptions make valid the causal path (green arrow) or mentioned statement based on back-door and front-door algorithms. One states that the perception of opportunities is influenced by the cultural adaptation, if and only if, by adjusting to next cohorts of students (see below), we confirm our hypothesis.

1) Cohort positive to the effect of speaking Norwegian and positive in the effect of having a part-time job on their cultural adaptation.
2) Cohort having access to Norwegian curses and positive on having a part-time job as part of cultural integration.
3) Cohort considering important having both Norwegian courses and Part-time jobs, for cultural adaptation.
4) Cohort noticing good opportunities on part-time jobs.

Figure 28 portrays the complete structure of the perception of opportunities for both: EU and Non-EU global talent using as basic the structure developed on figure 29 and adding elasticity factors due to variation on GT's opinions. Non-European residents are more likely to consider a part-time job to apply for a Job-Seeker visa after graduation but some of Non-EU students has scholarships or well accommodated family that can support them economically. Elasticity is therefore added because some of them consider more or less important to have a part-time job in order to fulfill the immigration financial requirement. The use of elasticity, and how it is calculated, is explained on **Appendix B**: Understanding Elasticity
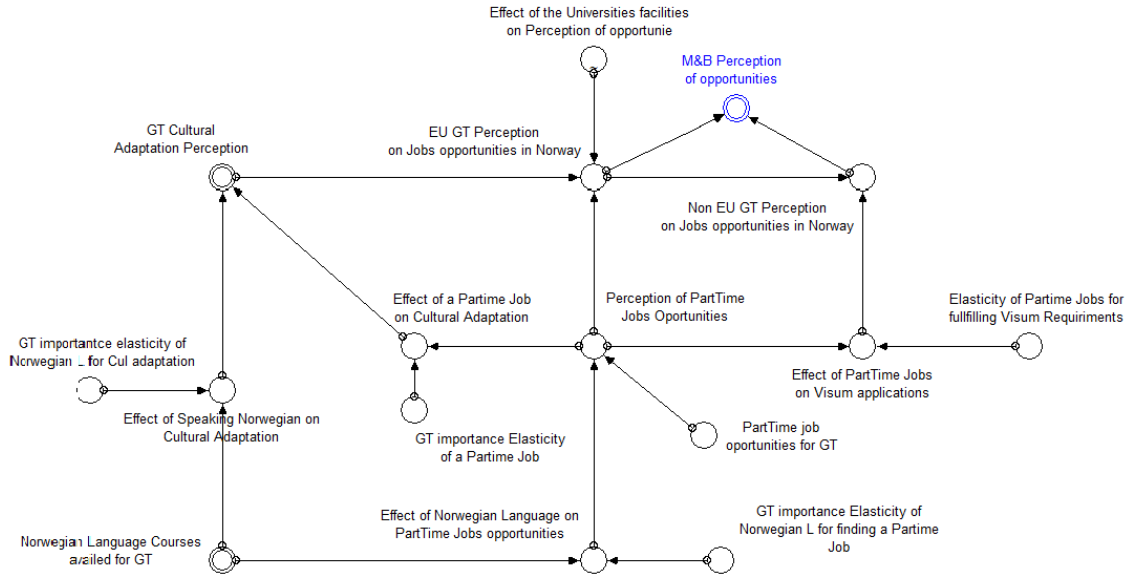
Figure 29: Entire Model of Perception of opportunities.

2.4.2 Modeling the Exogenous variables influencing the hiring rate:

In this section we develop a structural conditional model for modelling the fraction of global talent taking a job in the Norwegian labor market. This fraction is assumed to be the trust on the industry on the international graduate students, see figure 31. Figure 30 shows how this fraction feeds the Global Talent Population Model developed in section 2.1.
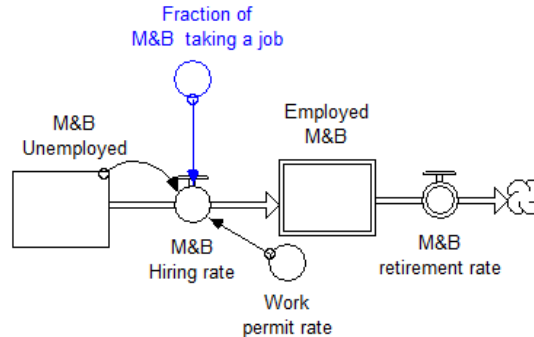

Figure 30: Hiring rate

1. *Background Knowledge:* Because of both the limited access to the Norwegian courses, and because a good command of the English language is required in order to be accepted to an international university program, the probability that a global talent get a job that requires English or Norwegian as working language cannot be the same.

❖ Therefore the probability that a potential GT occupies a job, where Norwegian is compulsory, is modeled as the subtraction of the probability that the same student would take an English vacancy minus the effect of speaking or not Norwegian. Thus the GT probability of taking any job vacancy is the mean probability of taking either an English or Norwegian job.

❖ The effect of speaking Norwegian on jobs applications is computed as the product of GT's access to Norwegian languages, times the probability that given a course he/she speak

Norwegian, times the elasticity that the industry determinates whether the Norwegian level is good or fair enough for that specific position.

2. *Background Knowledge:* According to DAMVAD data [2], there are more international students taking their first professional job in Norway within the public sector. Some question may arise: do international students prefer working in the public sector? Or could it be that the public sector (universities, research institutes, etc.) is more used to deal with international students than private industry? Or do Norwegian graduate students prefer the private industry due to higher salaries leaving less possibilities to international for compete?

❖ The probability that any global talent gets a job using only English is product of three modeled effects:
   1) Effect of trust of private international industry on potential GT
   2) Effect of trust of private local industry on potential GT
   3) Effect of trust of public industry on potential GT.

3. *Background Knowledge*: We split into 3 main categories, because they may have a different perception of their own needs when looking an employee. For instance, transnational companies brag that they look for competences on their employees rather their place of origin or education. We lack of the opinion of local companies, but data show that smaller fractions of GT are currently working on local companies while a large fraction works for the government. Thus Elasticity factors are modeled and differ from each industry sector.

❖ Perhaps our biggest assumption here is that the Industry perception on the GT's cultural integration, no matter the sector, is the same as the perception that Global Talent perceive on their-self. "You are what you believe yourself to be"

❖ The work experiences and its elasticity influence the hiring rate of potential GT. Finally there cannot be works if jobs vacancies do not exist; therefore we compute both Norwegian and English vacancies.
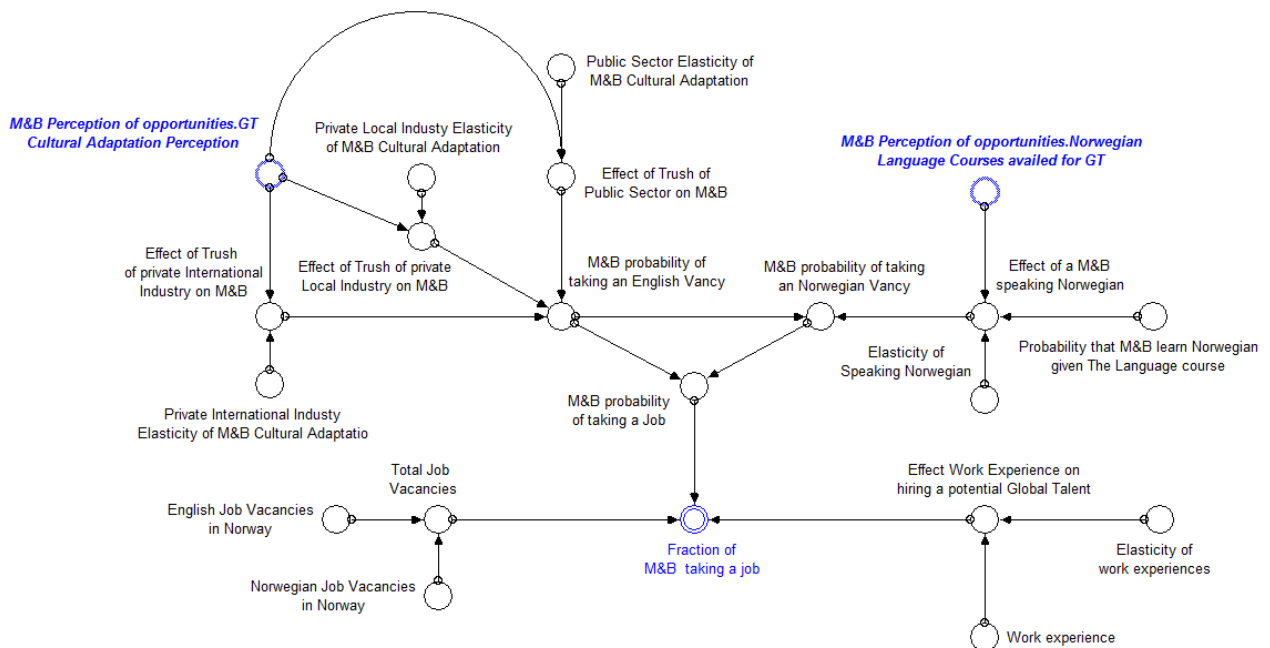

Figure 31:Fraction of M&B taking a Job

Chapter III

Testing the model's behavior

During the master program in system dynamics (SD), we have been taught the standard outline for a SD study. The outline often is memorized by the word: P'HAPI to remember the important steps of SD research: Problem (P), Hypothesis (H), Analysis (A), Policy (P), and Implementation (I) [23]. This section, "Testing the model's behavior", is about to (A) analyze the structure's behavior of all models developed in the previous section.

Previously many equations and parameters were discussed in each model and therefore it might be hard to remember or associate their impacts on the main problematic. Our testing strategy is presented on figure 32.
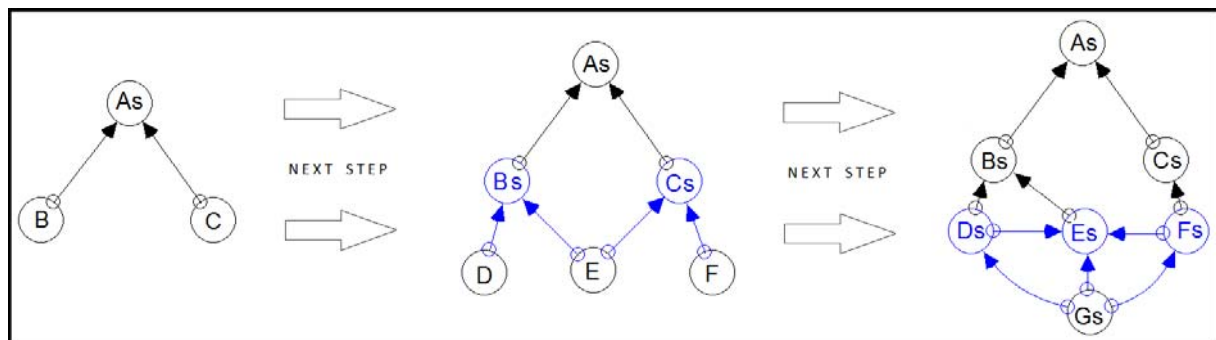

Figure 32: Three steps for our Testing Strategic.

The parameter "As" is the simulation of the historical data of the problematic "A". We know "B" and "C" causes our problem, and both are raw data. The first step is to proof that our simplest model is a fair representation of the raw data "A", i.e. the Euclidean distance A-As is cero or too small to be neglected. The second step is strength our model by disconnecting the raw variable "B" and "C" and plug their own models, the test consist on B+C-Bs-Cs=0 which inevitably leads to close the Euclidian distance A-As. The models "Bs" and "Cs" still depend on raw data (D, E, and F) at this second stage, therefore the last stage consists on avoiding dependence of historical data and plug only simulated variables (Ds, Es, Fs, Gs) which not necessarily need to be an structure, but also a graphical function or an equation; the result of the Euclidian distance A-As most ideally remains very similar to the first stage process.

One of the aims of this SD research is initially reproduce & model the dynamics of the fraction of Global Talent taking a job in Norway over the period 2003-2013. Many models and sub models structures have been developed and justify on section II. An overview about our testing section is next presented:

- Section 3.1:

It will explore the simplest model of the population of Global Talent from their admissions, to their job seeking process or decision to leave Norway. The model was developed on section 2.1.

The raw date of yearly admissions, the average fraction of GT leaving the country, and the average fraction of GT employed, will feed the model. The aim would consist on comparing the raw data Vs simulation. The stocks to look at are: 1) GT outside Norway, 2) GT inside Norway, 3) GT population, and 4) Employed GT.

- Section 3.2:

Here, a more complex population model developed through section 2.1.1-2, see figures 11 and 12, will be used. Some of the input data is simulated to make the model less dependent on raw data. But still raw data like the number of Norwegian High skilled workers, GT yearly admission rate, Annual Jobs, and Foreign High skilled workers will remain being our source. The aim again is look at 1) GT outside Norway, 2) GT inside Norway, 3) GT population, and 4) Employed GT, to compare simulation.

- Section 3.3:

It consists on having zero raw data dependency to run our model. Here all previous raw sources of data are simulated. Simulation of parameters such as: the number of Norwegian High skilled workers, GT yearly admission rate, Annual Jobs, and Foreign High skilled workers will be presented and explored.

- Section 3.4-3.5:

Another aim of this research is to evaluate the possible causal effect of the university-industry cross-cooperation on the current Global Talent problematic. The strategic is presented on figure 33. In section 3.4 three type of university-industry collaboration are discussed and we test the effect of each sub-model on the others. Section 3.4 consists on closing the gap between our proposed university-industry model, and the current behavior described by the literature.

Section 3.5 is to unify all models in one, the aim remains the same; the Euclidian distance A-As most remain very small. "As" should behaves very similar to "A".
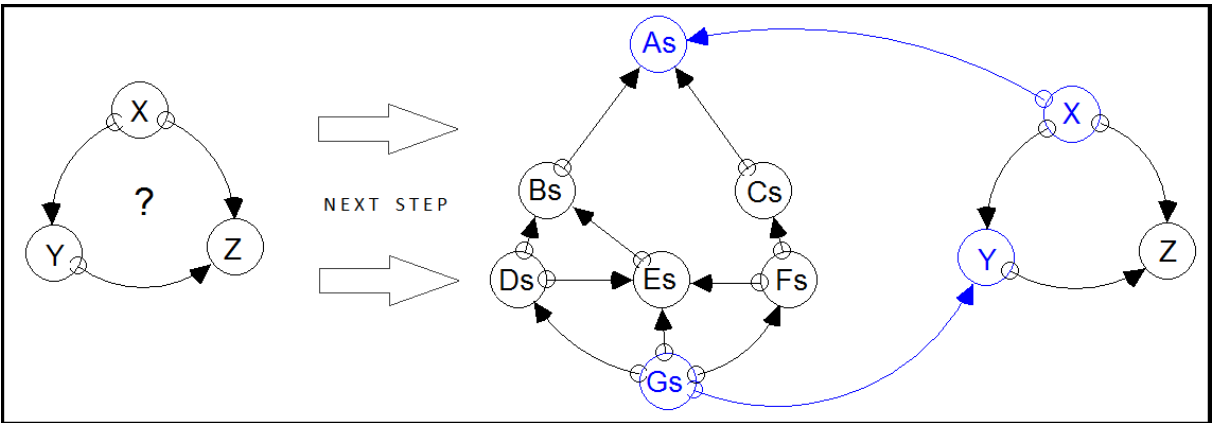

Figure 33: Testing Strategic for unifying the University-Industry model to the GT population Model.

3.1 GT population

In section 2.1, the simples GT population model was developed and explained. Students arrive to Norway each year to take higher education, as they successfully finish their educational program; GT starts their career path either in Norway or outside, see figure 34.
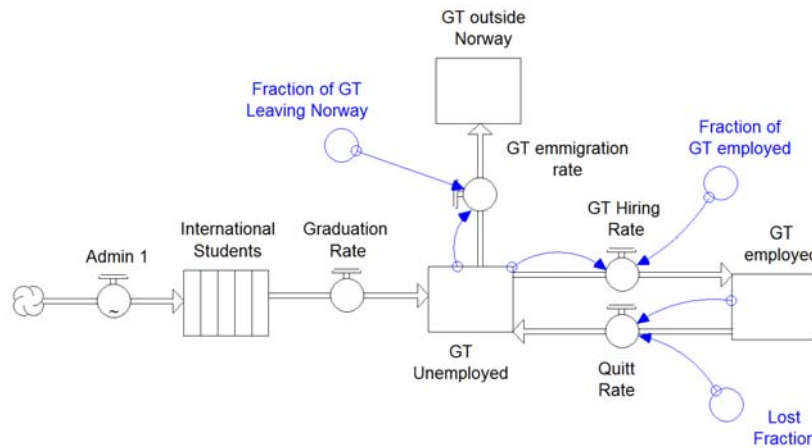

Figure 34: GT population Model

On the above figure the annual admissions, the average fraction of GT leaving Norway, and the average fraction of GT taking a job in Norway, are all find on the literature ([1-3]) and www.ssb.no. We are interested on learning their effect on the GT population dynamics. Figure 35 portrays the simulation results of the simplest GT population model. The red curve is the raw data of the problematic, while the blue curve is the simulation of the stock and flow model on figure 34.
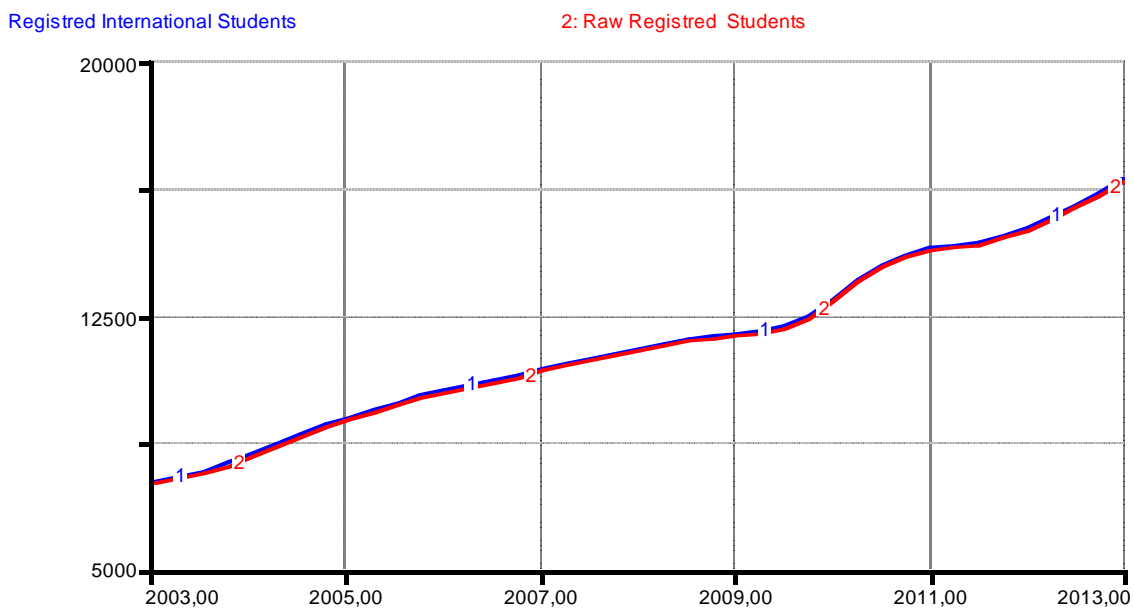

Figure 35: Raw data (RED) Vs Simulation (BLUE): Registered International Students

Euclidian distance between them (Raw-Simulation) is almost null as seen on the figure. The fraction of GT leaving Norway is set to 40%, the fraction of GT taking a Job is 56.6%, and the quitting rate is 4%. An annual admission is a graphical function of raw data and found on the appendix A. In addition, Figure 36 portrays the simulation results of "GT outside Norway", "GT inside Norway", and "employed GT". We believe the approximations are fair enough.
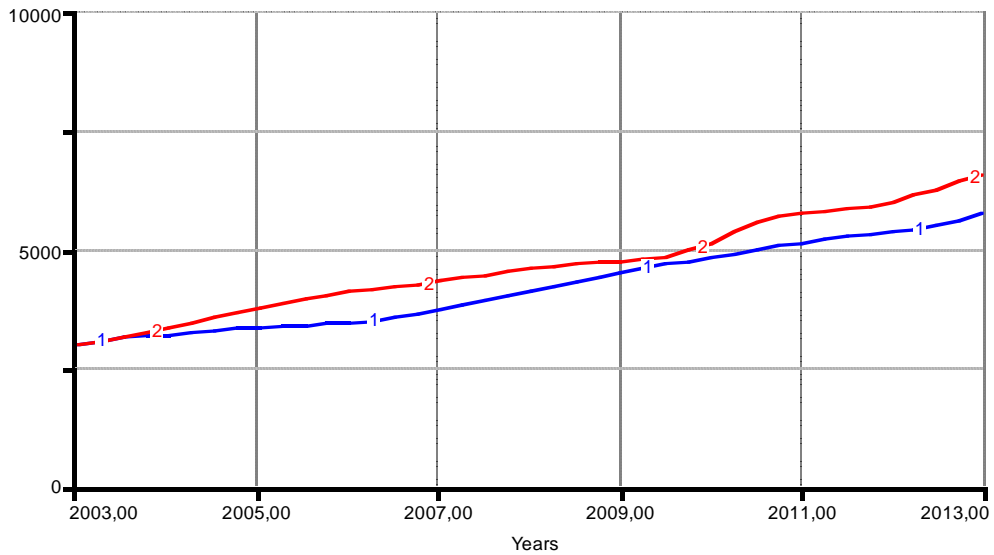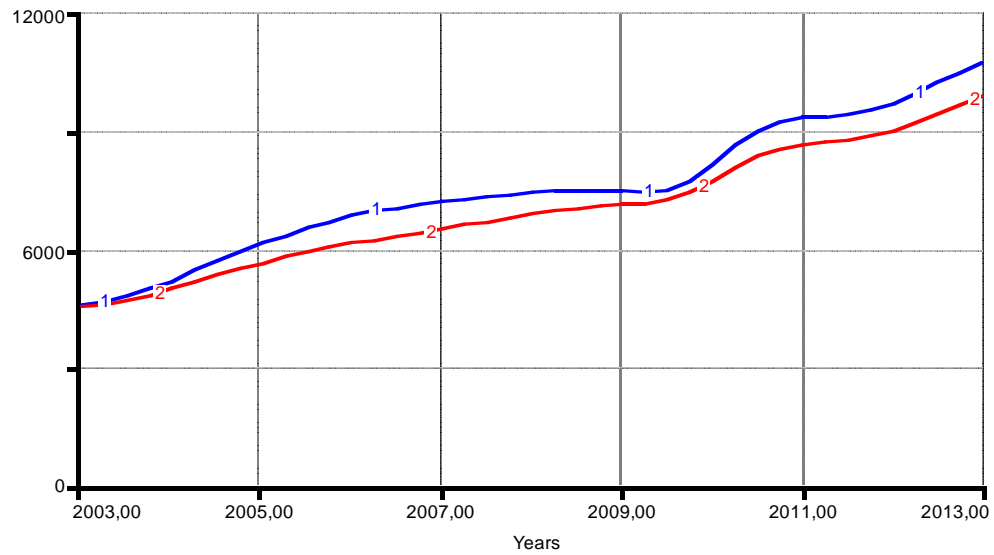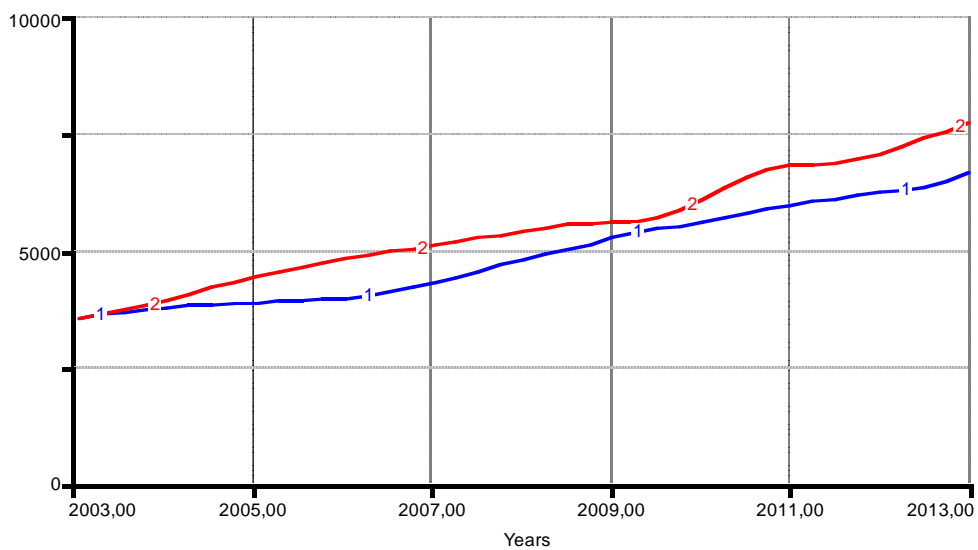
Figure 36: Simulation Vs Raw data. GT in Norway (middle graph), GT outside Norway (upper side), and employed GT (lower side).

3.2 A more elaborate GT population model

Ideas are usually spread word-to-word. In similar manner, GT's ideas or perceptions about job opportunities in Norway also propagates from one to another. Therefore, we re-design the GT population based on the word-of-mouth model to be as shown on figure 37.
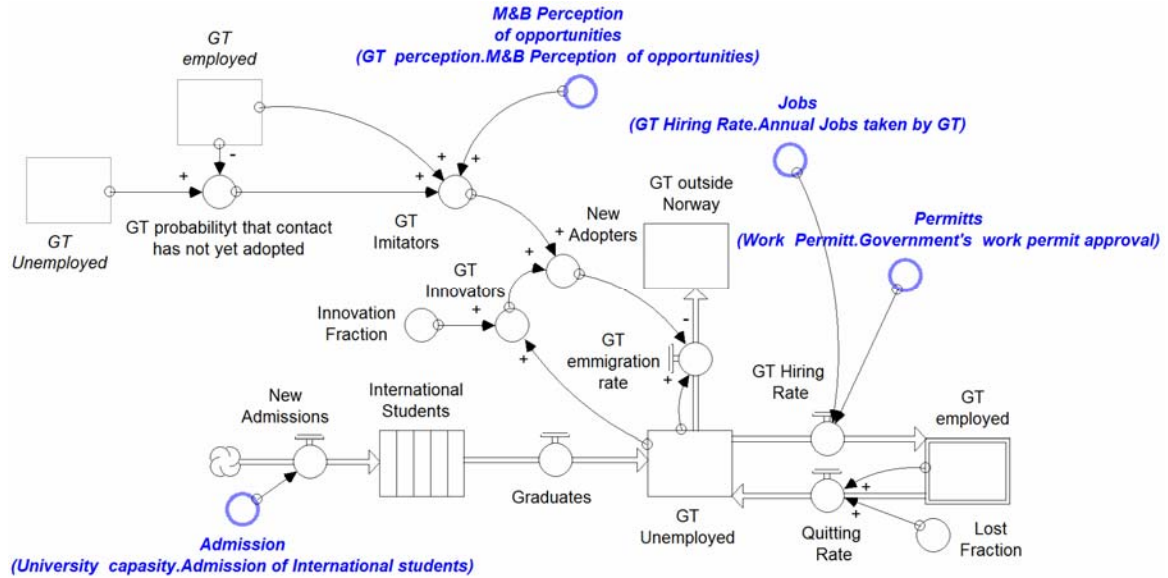

Figure 37: The word-of-mouth model for modeling the population of GT model.

On the figure, the blue parameters represent variables coming from other sub-models such as: University Capacity, Work permits, GT hiring rate, labor force, and GT perception of opportunities. To have an overall picture of the entire relationships between sub-models, we refer to figure 38. Our simulation-testing procedure is individually computing sub-models' data, and comparing with raw data. Finally we compute their effect on the GT population model.
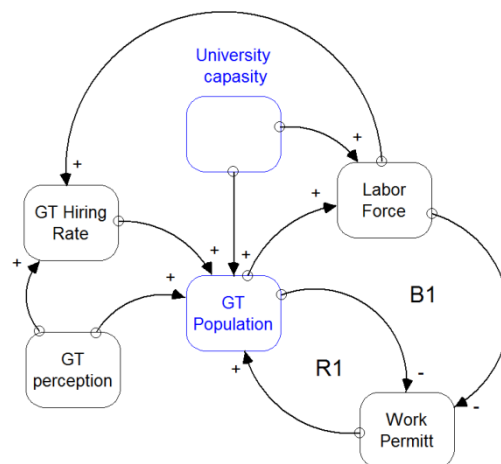

Figure 38: the GT model and its relationships with others sub-model.

3.2.1 University Capacity

In section 1.4 and on figure 7, the registered tertiary students in Norway can be found. From 2003 to 2013, there has been a steady growth in the number of Norwegian, International, and Exchange students year by year. Figure 39 contains the computed registered students.
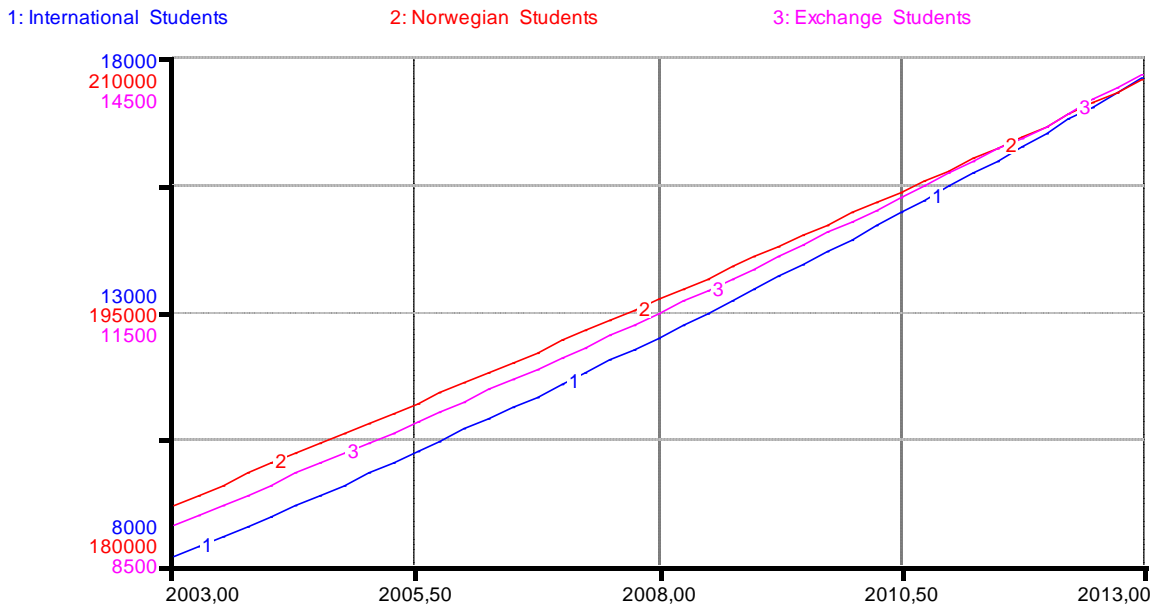
Figure 39: Tertiary registered Students. Simulation

On the figure, the dynamics of the registered Norwegian, International, and exchange students from 2003 to 2013 is found. Compering the raw data (figure 7) and the simulated results (figure 39), the comportment is alike; the population of registered students linearly increases. The increment is due admission rate. Figure 40 recalls the modeling process of the annual admission rate for Norwegian students; note that a similar diagram is used to compute the International and exchanges students' admissions each year.
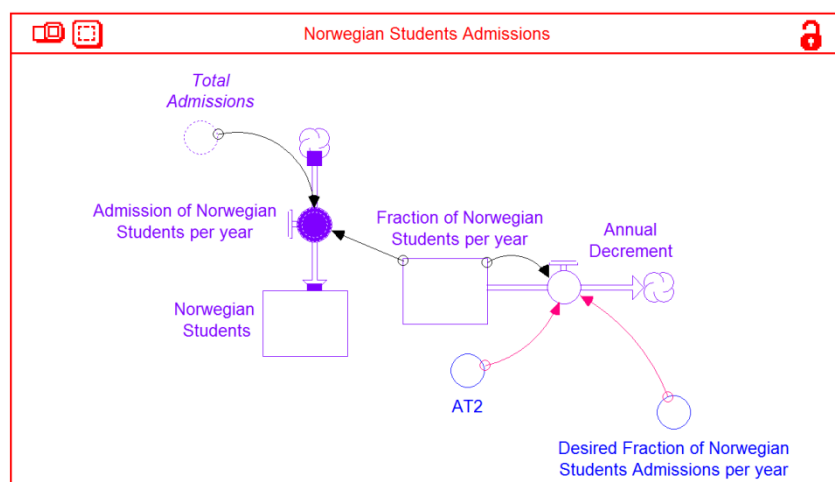
Figure 40: Admission Rate

Illustrated on the SFD on figure 40, the admission rate depends on the "total admissions" parameter, which is explained in the modeling process section, but our interest to compute such admissions as they feed other sub-model. The admissions' simulation is plot on figure 41.
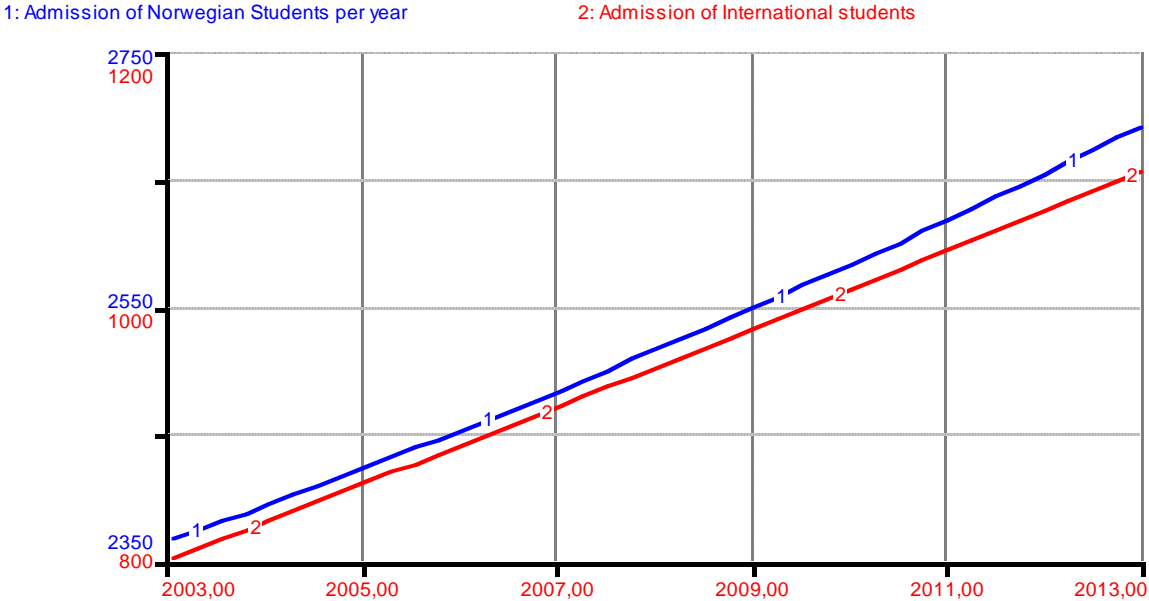
Figure 41: simulation of university admissions.

3.2.2 Labor Force model

The Norwegian Admission rate is used to estimate the registered Norwegian High Skilled Workers (NHSW) population. See figure 42 which is only part of the entire Labor force model developed in section 2.3. Our Test here, consist on compering the raw data of high skilled workers again the simulation.

Figure 42: Norwegian High Skilled Workers model

43

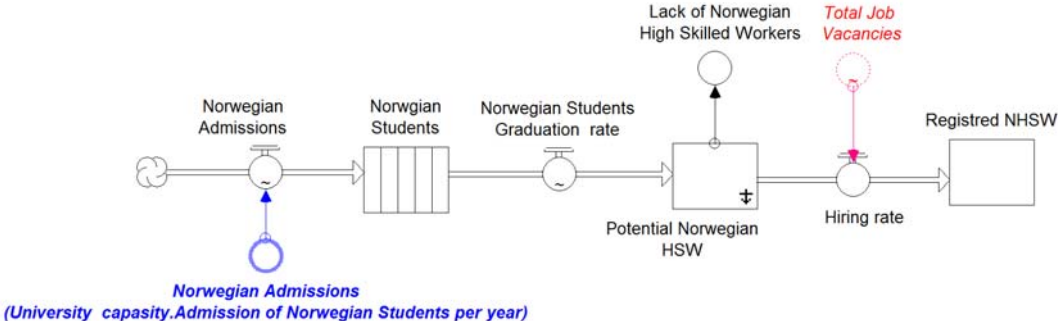The red parameter "Total Job Vacancies" is the annual job rate or amount of jobs that are published, according to SSB and NAV institutions in Norway, each year. We use NAV and SSB's raw data at this current simulation point. Figure 43 shows a computation of the registered NHSW (blue, plot 1), foreign workers FHSW (Red, plot 2), the potential Norwegian HSW (green), and the lack of Workers (pink, plot 3).
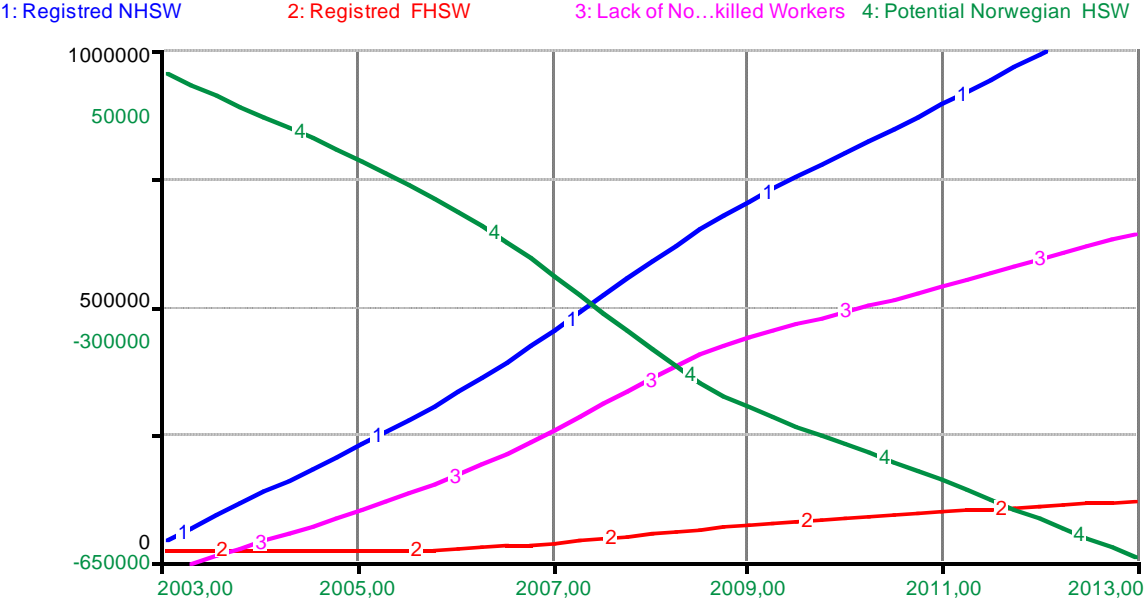

Figure 43: Simulation results. Labor force

The registered Norwegian and Foreign high skilled workers population from 2003-2011 is presented in section 1.4 figure 5. For our testing process, we believe the result on figure 43 indicates this is another reasonable approximation of simulation to raw data.

It can observe that the "Potential Norwegian HSW", the green line 4, gradually falls up to negative values, this trend might explain the need of looking for HSW abroad. It seems that industry is free to hire people as needed. On the same figure 43, pink line 3, The "Lack of Norwegian Skilled Workers" might justify the government's policy when approving all FHSW's visa applications, which in proportion to the actual need; it is still a small fraction.

3.2.3 GT hiring and Perception of Opportunities models:

When it comes to hiring of graduate international students or Global Talent GT in this document, DAMVAD has conducted an interview about the perceptions of GT on job opportunities in Norway, and has also interviewed to some Norwegian and International enterprises to know about their hiring process [2, 3]. In section 2.4, we have modeled exogenous data about what provokes the student's perception of opportunities in Norway, which in turns mean the same confidence the industry perceive from them about their cultural adaptation in the country. The "GT probability of taking a job" is the result of all this exogenous modeling, and it causes the fraction GT working in Norway each year "Annual Jobs taken by GT". The computation result is presented on figure 44
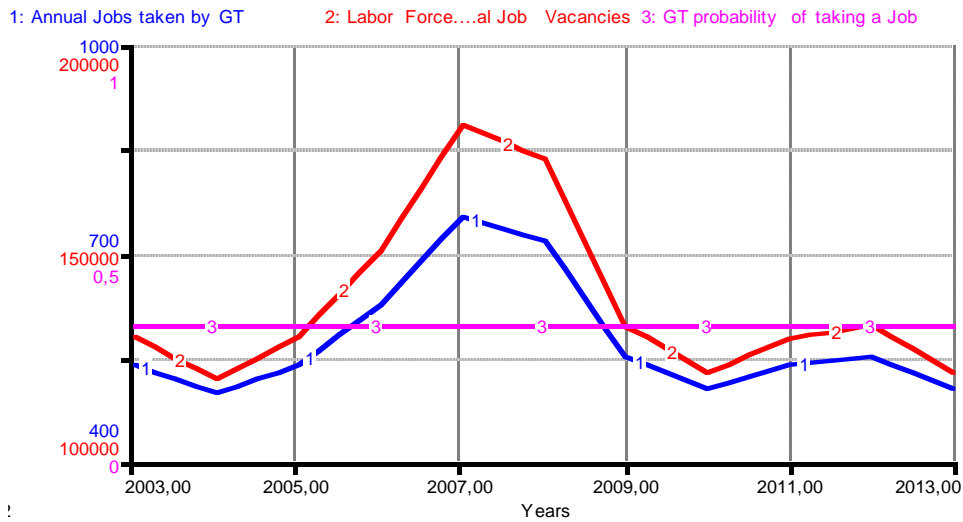
Figure 44: Simulated Annual Jobs taken by GT. Total Jobs Vacancies. GT probability of taking a Job

On the figure, it can be observe the probability that GT take a Job in Norway is less than a half and about 33%. Therefore the number of GT taking a job vacancy (Blue line 1) is relatively low comparing to the actual market's need (Red line 2).

The main objective of the simulation and testing section is to close the gap between raw data and simulation result on the Global Talent population, this means to plug all sub-models results into the GT population model and simulate their effect. Figures 45-47 contain the results.
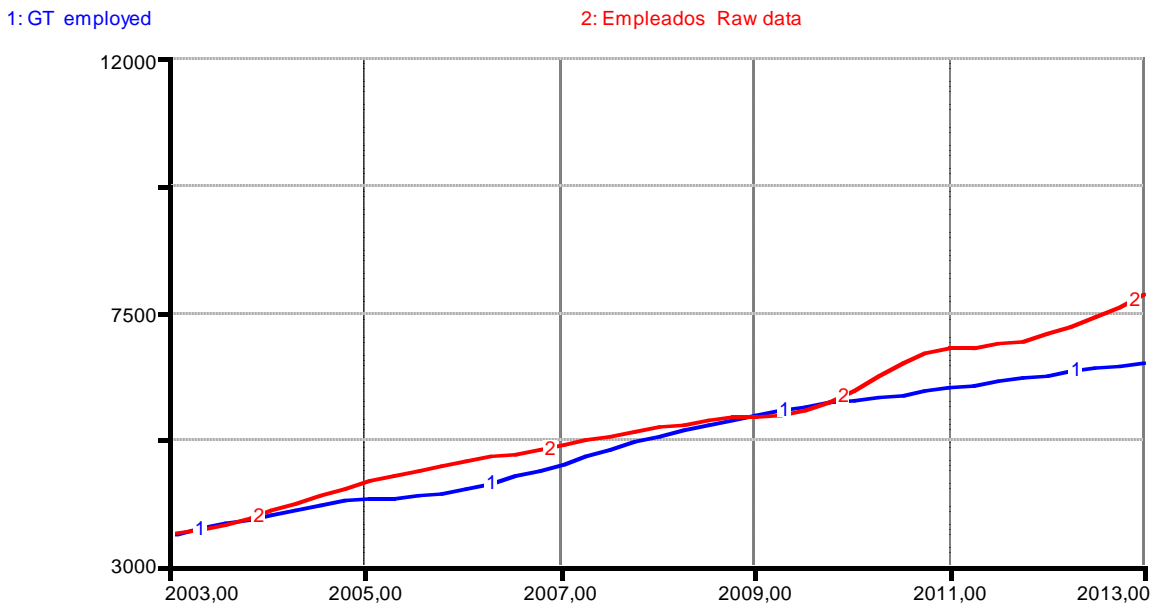
Figure 45: GT fraction of people having a professional job. Blue represent the simulation, Red is raw data
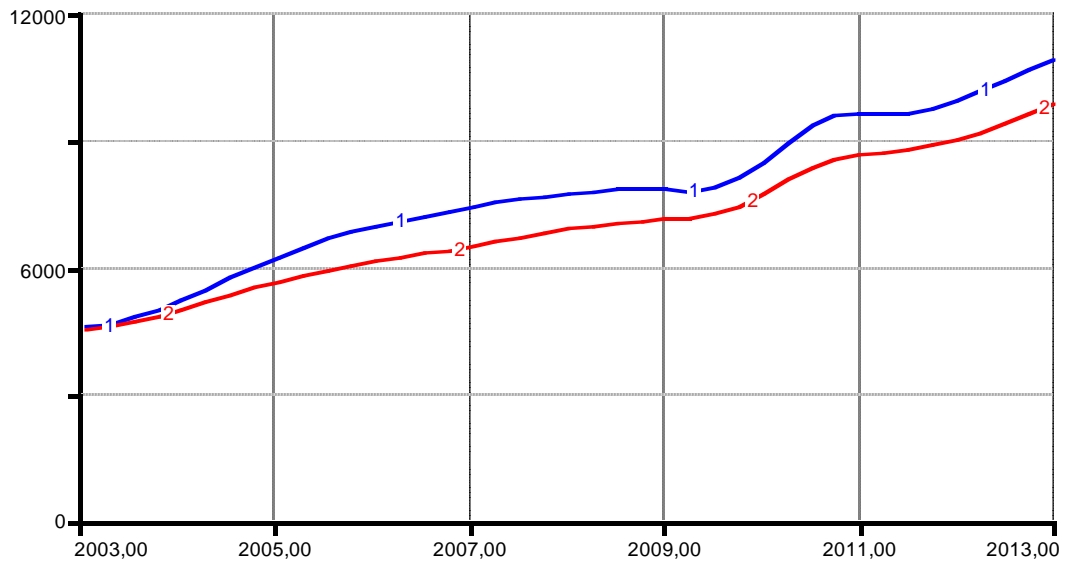
Figure 46: GT in Norway. Simulation (blue) Vs Raw data (Red)
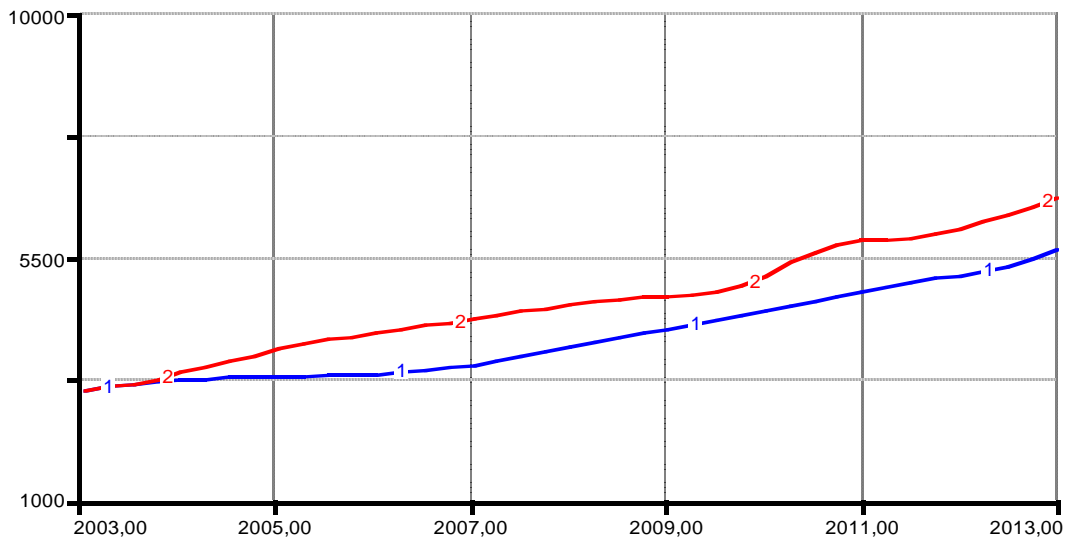
Figure 47: GT outside Norway. Simulation (blue) Vs Raw data (Red)

On figures 45-47, the number of "employed GT", "GT living in Norway", and "GT outside Norway" can be observed. Both simulation and raw data are presented. We might conclude the simulation data closely matches and fairly approximates the behavior's pattern of raw data. It is often difficult to null the Euclidian distance between the problematic' raw numbers and simulation, especially when the model is composed of many sub-models; the more approximations, the grater Euclidean distance of the total objective function. However, we believe our results are good enough to describe the problematic, and begin to make a policy that solves needs.

3.3 Simulating the annual Job rate for the GT population model

In this section we make our model completed independent on raw data to be run. The annual job vacancy for high skilled workers' parameter is plot on figure 25 (blue curve). The Norwegian labor and welfare department publishes statistical data about all jobs position in the country annually.

On figure 48, the job rate has oscillated over the period 2003 to 2013, and its shape is similar to a Mexican Hat.

The Cardinal Sine function or SINC function is commonly used in engineering and signal processing sciences to sample or fit a curve. Its amplitude in time domain comes from the idea that rectangular pulse can be fit by adding sub-harmonics sine functions [21]. The SINC function is also known as the Mexican Hat (Sombrero) function which equation is next described:

$$Sinc\ (x) = \begin{cases} 1, & x = 0 \\ \dfrac{\sin(x\pi)}{x\pi}, & x \neq 0 \end{cases}$$

In iThink software, we are not able to find such equation or function and therefore we have computed a summation of sine and cosine functions. The result is plot on figure 47 (Red curve). The pattern it's also a SOMBRERO shape but slightly left-shift.
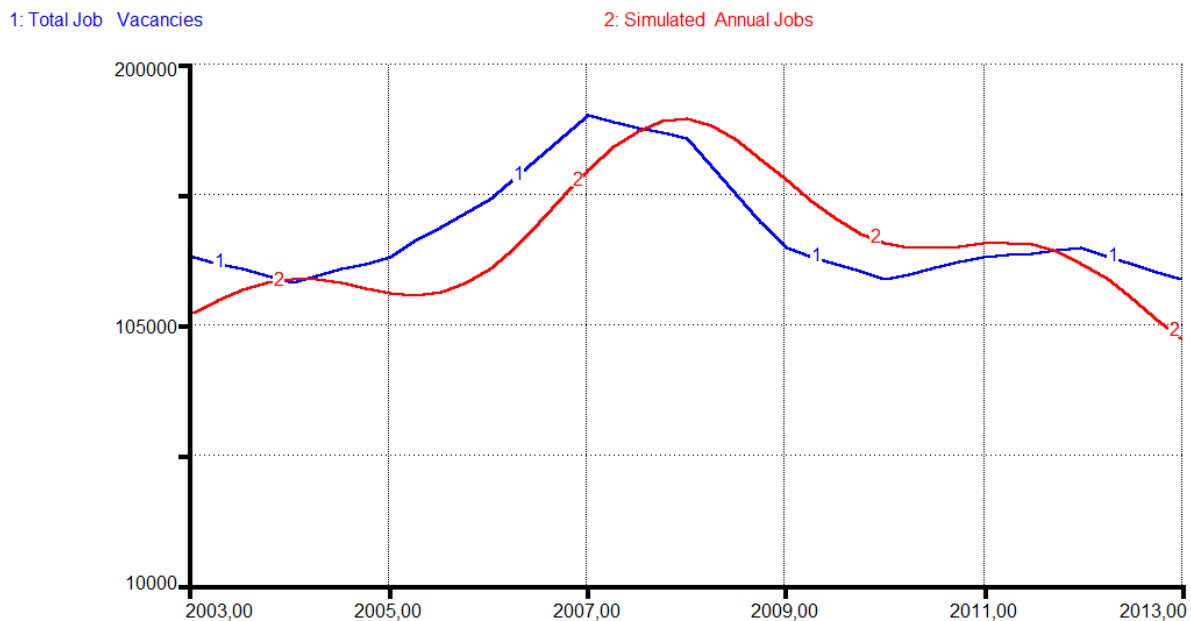
Figure 48: Annual Job Vacancies. Raw data and simulated data

This "Total Job vacancies" parameter is very important in our model, because this explains the labor force dynamics in Norway and affects the hiring rate of Global talent (Graduate international Students) as seen previously.

47

Figures 49 to 51 show the effect of the emulated Annual Job rate on the GT population Model, we pay attention to the GT fraction living and outside Norway, and as well the employed GT.
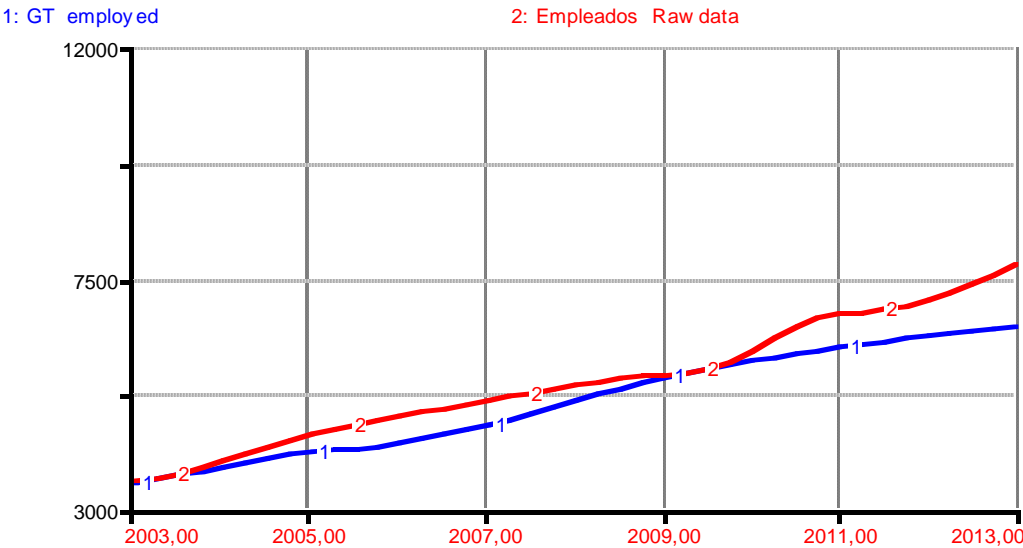
Figure 49: Employed GT. Raw data (RED) Vs Simulation (Blue)
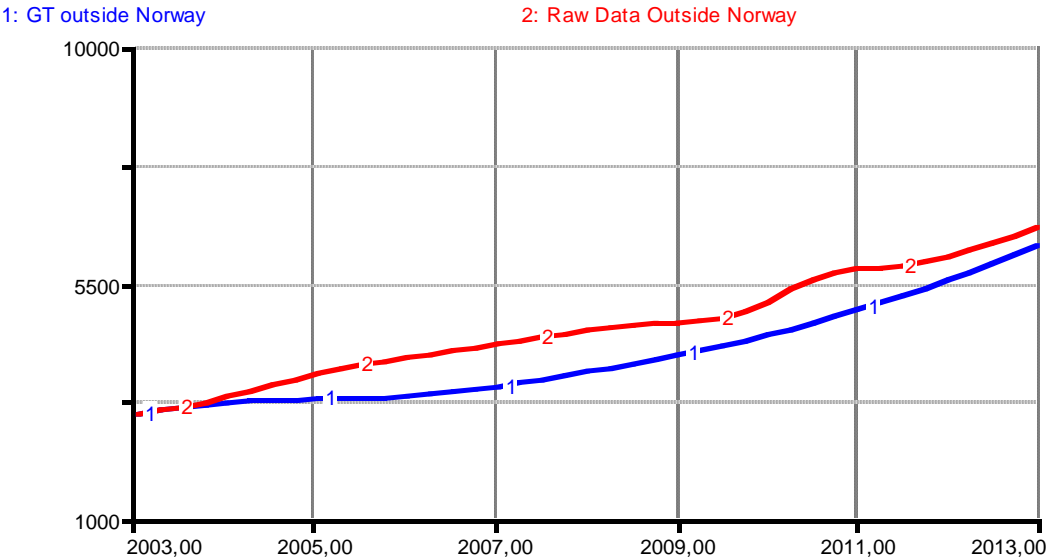
Figure 50: GT outside Norway. Raw data (RED) Vs Simulation (Blue)

The employed GT remains very close the fit raw data on figure 49. However, the simulated GT living and outside in Norway on figures 50 and 51 shows a gap in the period 2007-2009 when comparing with their respective raw data. This mismatch is quickly explained, look at the same period on figure 48 (annual Jobs), there is a shift on simulated jobs causing the same effect on the GT population parameters as expected. However we believe the approximation are fair enough to move on since it behaves very similar.
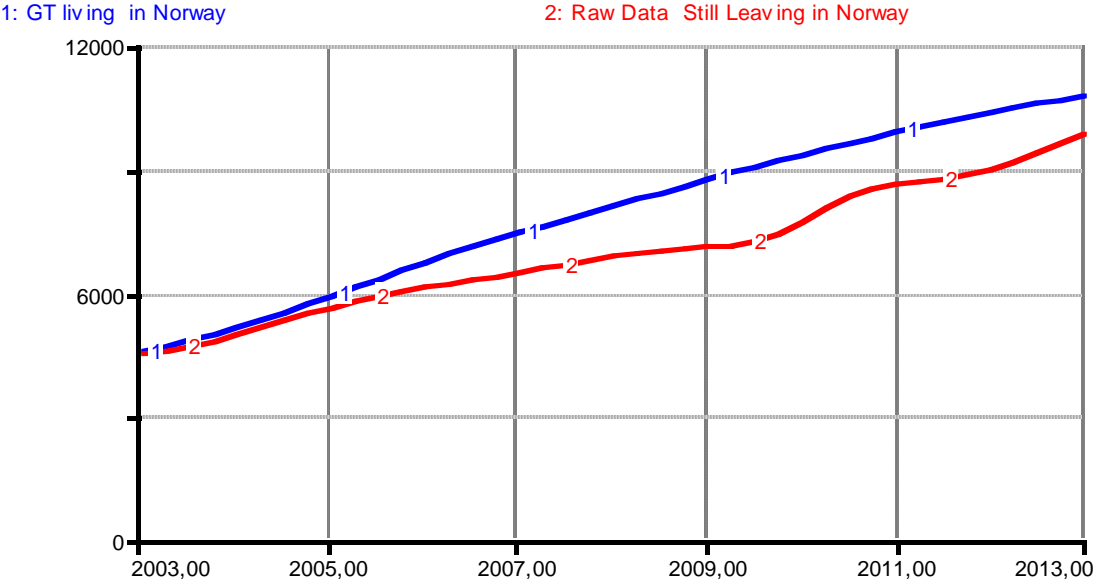
Figure 51: GT in Norway. Raw data (RED) Vs Simulation (Blue)

3.4 Analyzing the University-Industry Cross-cooperation

The university-Industry cross-cooperation has been discussed in section 2.3. We have proposed and developed a stock and flow model for evaluating the current university-Industry collaboration in Norway. Our Model is based on the empirical knowledge obtained by observing the cross-collaboration's dynamics of some institutionalized University-Industry research CRIs, and some large project where both, university and industry, participates [22].

R&D, teaching & specific programs, and a third mission; are the three forms of University-Industry evaluation in our modeling process. The aim of this section is basically to get familiar with the 3 types of University-Industry cooperation's models, from their individual dynamics, to their integration to each other.

3.4.1 Understanding the R&D University-Industry cooperation model:

Two main mechanisms have been emphasized as the instruments for fomenting the first type of collaboration between the academia and private institutions along this document. The first instrument is known is the "Tax Deduction Program" which pushes Industry towards a goal on R&D cooperation with a public research institution [7, 8, 22]; Industry cooperates to reach it maximum amount of tax deduction. The second apparatus to strong the relationship between academia and industry is the access to public funding, which is a reinforcing loop [20];

Figure 52.C recalls the R&D Stock and Flow model of section 2.3.1. The increment rate of the "current R&D" stock is provoked by the two reinforcing and balancing mechanisms previously described. On the same diagram (C), the stock "Percentage of Tax deduction" is a goal seeking process, which can be observed on figure 52.B. In addition, the "effect of funding on R&D" parameter causes the reinforcing behavior on 52.D.

The plots of figure 52 are comparative simulation to evaluate the effect of each instrument and their combined effect. If there were none other effect than the "Desired Collaboration Due to Tax Deduction", the "University Current R&D" (51.D) would only move towards a goal; but because of the reinforcing loop caused by the "effect of funding on R&D" parameter, the "University Current R&D" starts gradually to increase after the balancing behavior.

One must figurate: what is causing such "effect of funding on R&D" parameter? In section 2.3.1, we have explained the mathematics for figure 53. In contrast to the deduction program, there is not limit here on the number of calls to participate for funding. Industry might be interested on participating, as its previous R&D experience with an academic partner, is. Empirical studies indicate that the involvement or interaction in CRIs and projects varies much, from almost day after day collaboration to clearly mostly symbolic relations [22].

Our next simulation purpose is to understand each stock and parameter on diagram 53. Industry's profit crafts the effect of the reinforcing loop on figure 53; its outcome is the "effect of funding on R&D" parameter, whose effect was previously understood on figure 52.
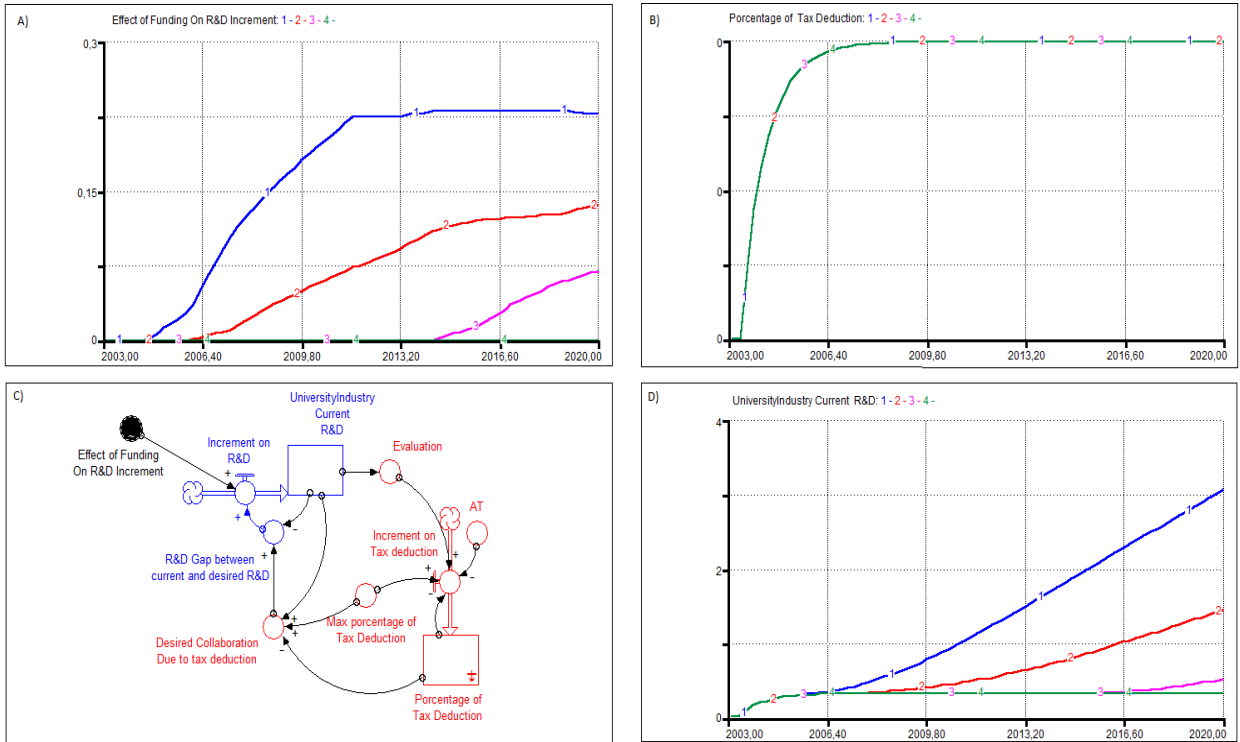
Figure 52: A) Effect of Funding on R&D. B) Percentage of Tax deduction. C) R&D University-Industry SFD. D) Current R&D

In the modeling process, the "Profit Growth rate" is the summation of both: "Growth of funding" and "Growth of Profitable IP". The first one depends on the same positive loop, while the second parameter does not. By profitable IP is meant the percentage of intellectual property produced and registered by the University-Industry Consortium, which increase returns. Figure 54 shows a comparative simulation of the effect that such "Growth of Profitable IP" has on each stock within the reinforcing cycle on figure 53.
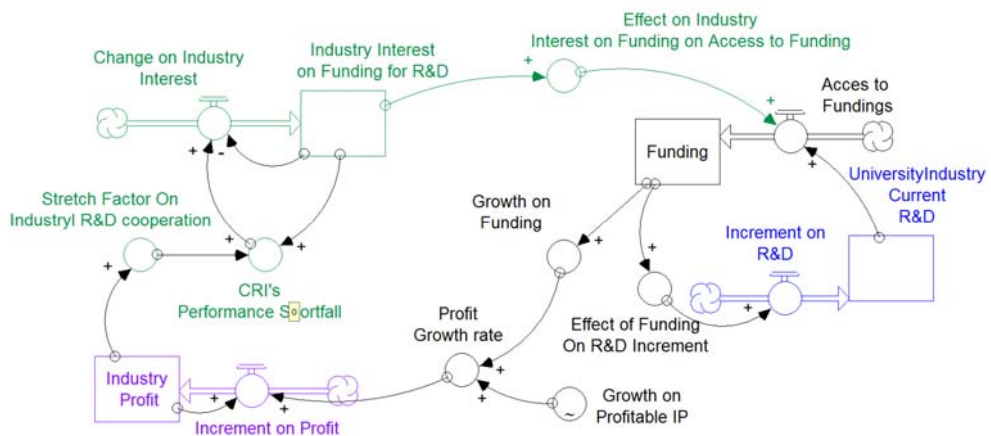
Figure 53: Structure behind the Effect of funding on R&D

51
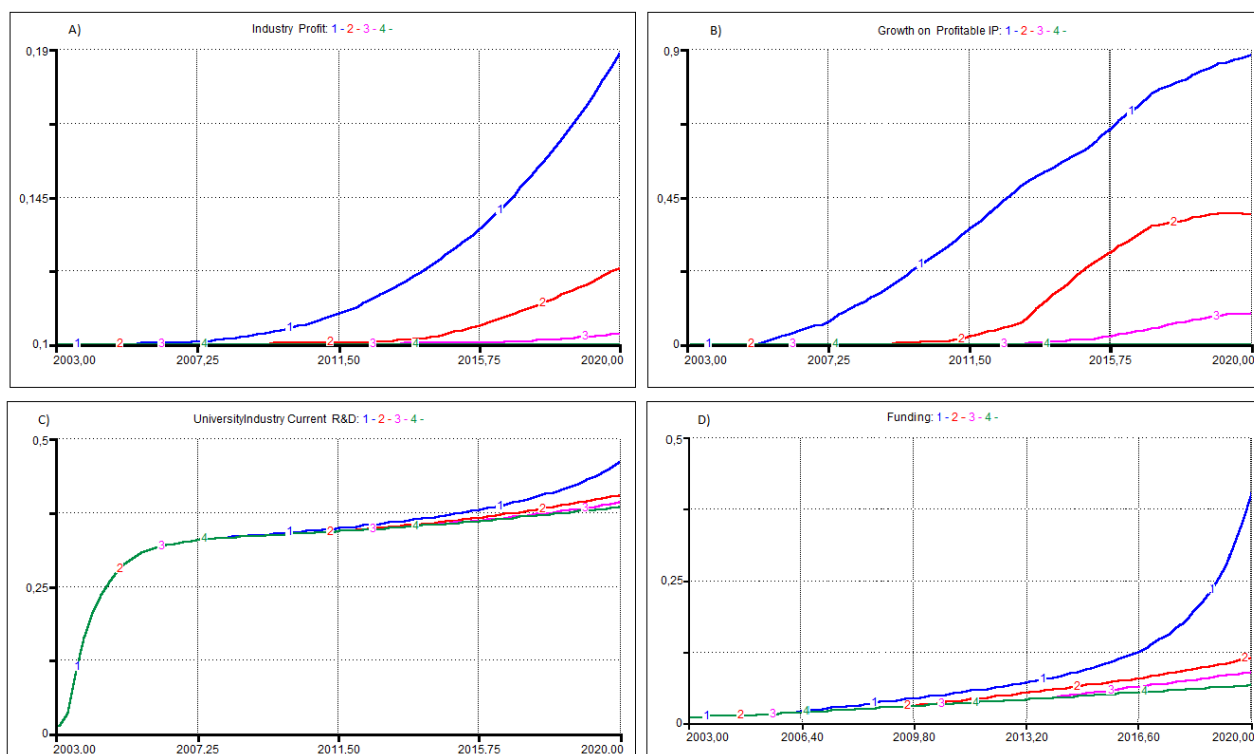
Figure 54: A) Industry Profit. B) Growth on Profitable IP. C) University-Industry R&D. D) Funding

On figure 54, if there is a lack of profitable IP growth (B), there won't obviously be industry's profit (A), but University and funding would remain increasing until the effect of interest on funding stock becomes null and the tax program reaches its goal. Conversely, a notable increment on profitable IP leads to a significant rise on Funding and R&D; Industrial profit would therefore shoot up.

3.4.2 The TTOs-SIRD model for a third University-Industry collaboration

The "Profitable IP" is the crucial outcome of the university' technology transfer offices (TTO's), which in section 2.3.3 is modeled using the SIRD population model. Basically of all "potential research" that TTOs adopt "Adopted R&D", a fraction of it, hopefully will become a fruitful IP in terms of income or profit. In addition, if TTOs fail when choosing the most promising IP "useless IP", instead of generating profit, it represents a waste of money, effort, and time.

On the left side of figure 55 portrays, the SIRD model structure developed in section 2.3.3 is found. Its typical behavior, given a fix "Potential Population" (Potential Research), is plot on the right side. The graphs on figure 55, because there is no inflow to the "Potential R&D" stock, its behavior is an exponential decay curve formed as the TTO's adopts R&D; taken to a commercialization and patenting process. The typical behavior of the "Adopted R&D" stock, or "Infected People" on the SIRD model, typically rises until the "Potential R&D" empties, then gradually starts going down if either the "market's adoption rate" or the "TTO's failure rate" are active. The "Profitable IP" and "Useless IP" stocks, on the hand, will goal seek; their goal level is relative to the "market's adoption rate" and "TTO's failure rate".
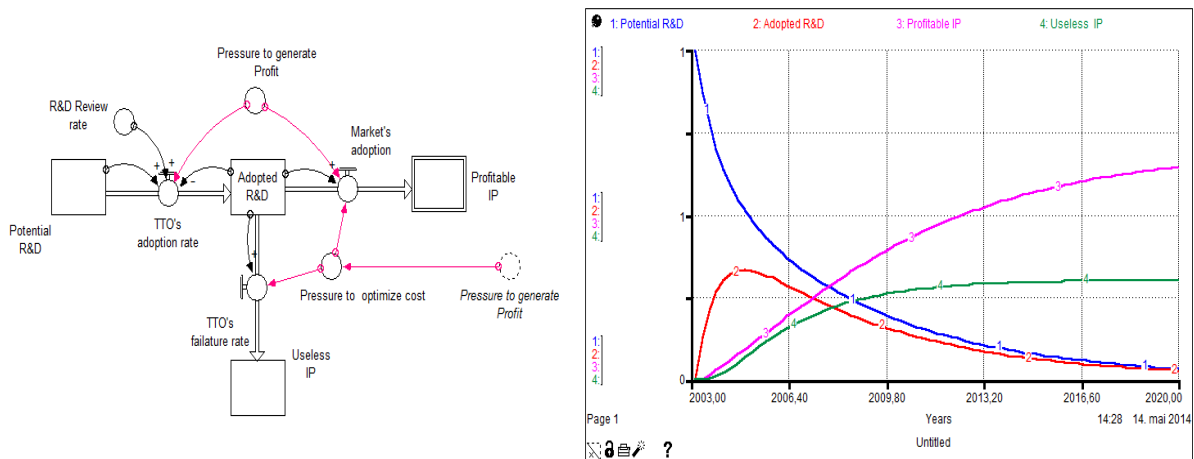
Figure 55: SIRD model used for computing the TTO's IP management

In Our TTO's SIRD model, there exist a constant inflow to the "potential R&D" , and because this inflows is a function of the "Current R&D" stock of figure 53 which in theory is gradually growing , the "potential R&D will fluctuate, the "adopted R&D" will look for a goal, and both, "Profitable IP" and "Useless IP" stocks, will constantly growth according to the "market's adoption rate" and "TTO's failure rate" respectively.

We must notice on figure 55, that the "pressure to generate profit" influences the "TTO`s adoption rate", "market's adoption rate" and "TTO's failure rate". In the model, the Pressure to optimize cost is the inverse to it, because IP is only classified as either "Profitable" or "Useless". Before moving on, it is very important being cognizant of the effect that the "pressure to generate profit" has on the SIRD model, or specifically of its effect on the "Profitable IP" stock's behavior.

Figure 56 is another comparative computation. The effect of the "pressure to generate profit" on the "Profitable IP" stock is clearly inferred. The higher the pressure to generate profit is the more profitable IP; conversely, the less pressure, the worse profitable IP level.
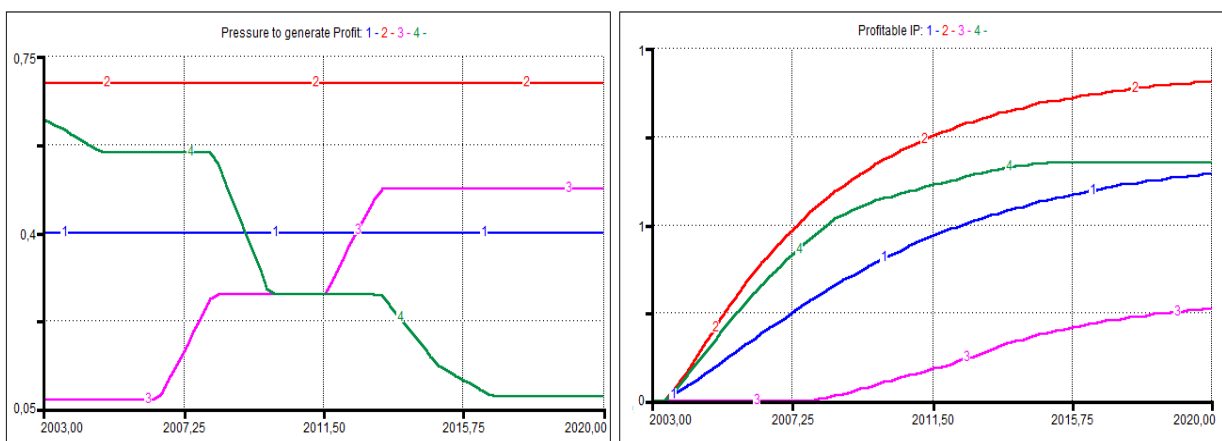
Figure 56: Comparative results of the pressure to generate profit and profitable IP

53

At this current point, one should be very familiar of the two models of figure 57, and its behavior separately. Notice these are 1) R&D, and 2) TTO's SIRD. Now our next intention is to simulate their behavior when plugging each other, because now both of them, the "Growth on Profitable IP" and the "Pressure to generate Profit" form/are a secondary reinforcing loop, which is extremely difficult to control because they depend from each other.
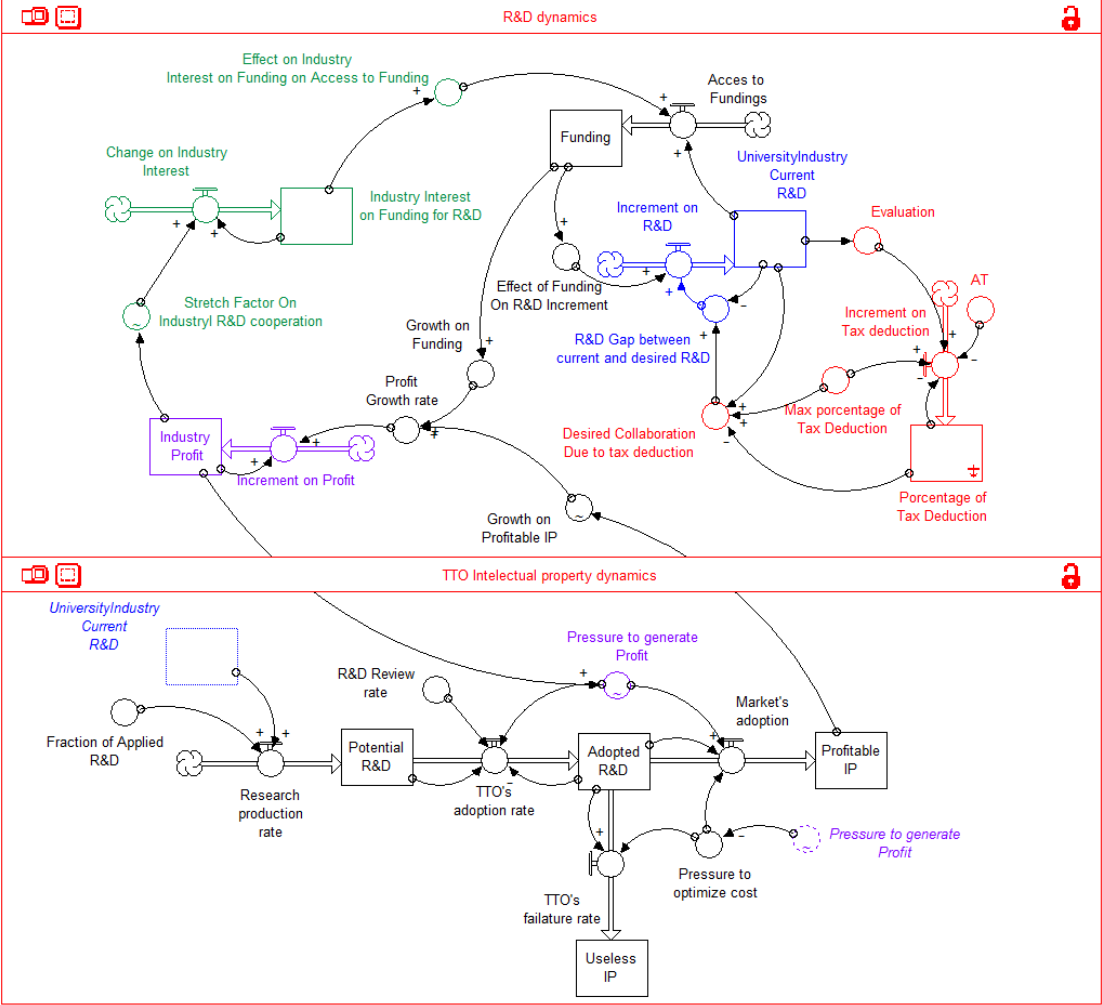
Figure 57: Interconnecting two types of University-Industry Collaboration. 1) R&D 2) IP

Previously, we have remark that since the creation of TTOs, their performance have not been the ideal, but rather poor and its behavior is flat, if by evaluating the amount of patents, a big fraction is not currently generating a valuable profit to the university-Industry consortiums [7,8]. Our main objective is therefore reproducing such described dynamics. Some of the learn: 1) "Profitable IP" increases the "Industry's profit", 2) the "Industry Profit" raises the "Profitable IP", and 3) Null "Profitable IP" means zero "Profit". The last point is a hint, not only because the scientific literature indicates that the current TTOs' performance have been unfortunate, but also because a high initial value, either "Profitable IP" or "Industry's Profit" stocks, would make to the reinforcing loop, formed by them, immediately takes action. One must optimize their initial values.

54

Figures 58 and 59, contains the resulted simulation of figure 57 model for two different initial values of the "Industry's Profit" stock. Both figures show its influence on the others stock's behavior over time. On figure 58, the reinforcing loop created by plugging the SIRD model to the R&D model is not triggered; the Profitable IP values are flat (C) leading to the Profit to also remain flat (D), and consequently the industry interest on funding is also low and monotonous. Funding and University current R&D (A) keep fairly increasing because of the tax deduction mechanism, and the secondary positive loop between the current R&D and Funding Stocks.
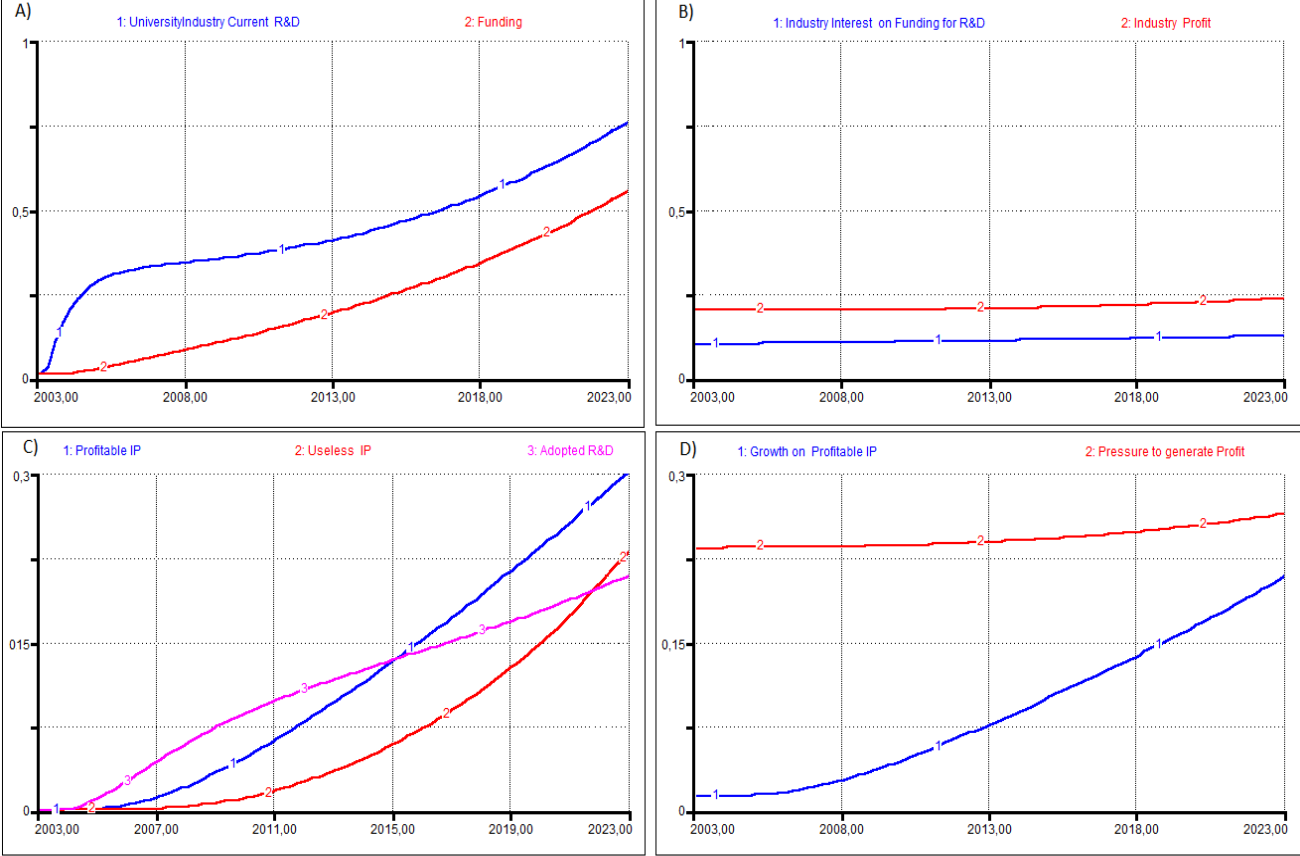
Figure 58: comparative results of R&D cooperation, Industry Profit, Growth on Profit and IP

Nevertheless, if we increase the initial value of "Industry Profit", it triggers all reinforcing loops on the model of figure 57. Profitable IP and Interest on Funding stock gradually start lifting up, and there is a significant change on the growth rate of the "current R&D" and "Funding" stocks.
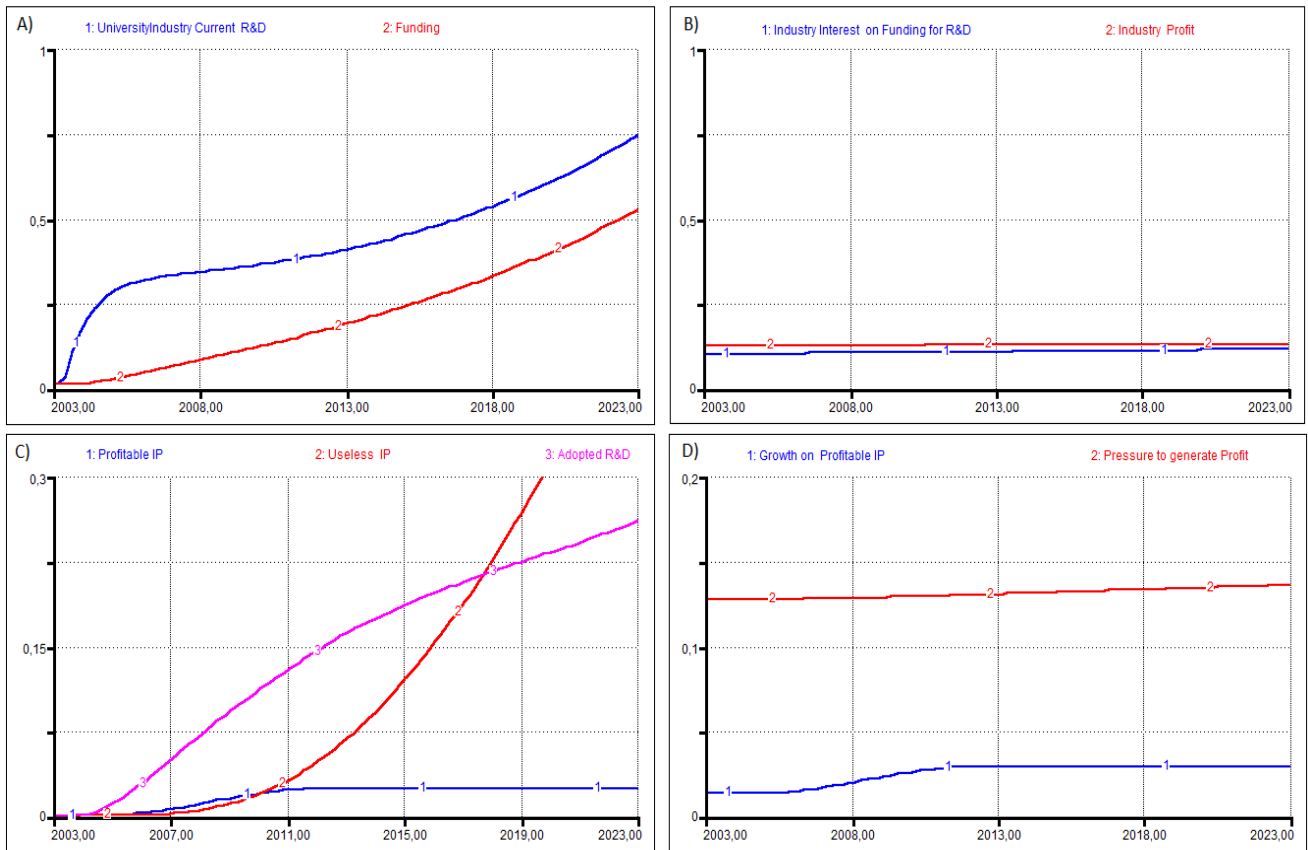
Figure 59: comparative results of R&D cooperation, Industry Profit, Growth on Profit and IP

3.4.3 The CRIs employees model; University-Industry: Teaching and Specific Programs

CRIs are so far the most relevant evidence of the teaching and specific programs agreed by the University and Industry as another type of collaboration. [7, 8]. For basic and also applied research, many PhD and Post-docs projects have been created. This job positions have been specifically related to a project that combines academic research with innovation; a more practical or industrial related [22]. We assume the CRIs are a job source not only for researcher, but also for technical staff having a master and bachelor degree, i.e. high skilled workers.
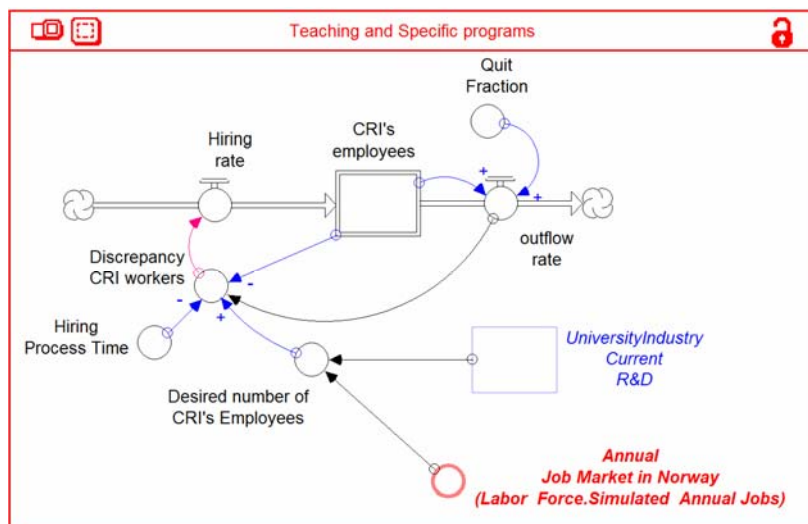
Figure 60: Teaching and specific programs

Figure 60 reveals a stock and flow diagram of the CRI's employee's dynamics. For system dynamics experts, it is very easy to deduce the model is a balancing loop, sometimes known as goal seeking models. The hiring rate of future CRIs' employees is the discrepancy between the Desired CRIs' employees and the current employees. We have modeled the Desired Goal as function of the "Current R&D" stock, on figure 56, times the Annual Jobs previously modeled in section 3.3.

Figure 61 and 62 are the simulation results. On figure 61, the numbers of current and desired employees are plot. In addition, figure 62 gives the computation of the CRIs' hiring rate, and recalls the simulation of the Annual Job vacancies. We must pay attention to the simulation of the hiring rate, because its behavior is fair replica of the raw data of the number of annual jobs in the public sector presented in section 1.3.2 figure 6. We must emphasis that CRI's employees are considered as public employees even though salaries come partially from the industry side.
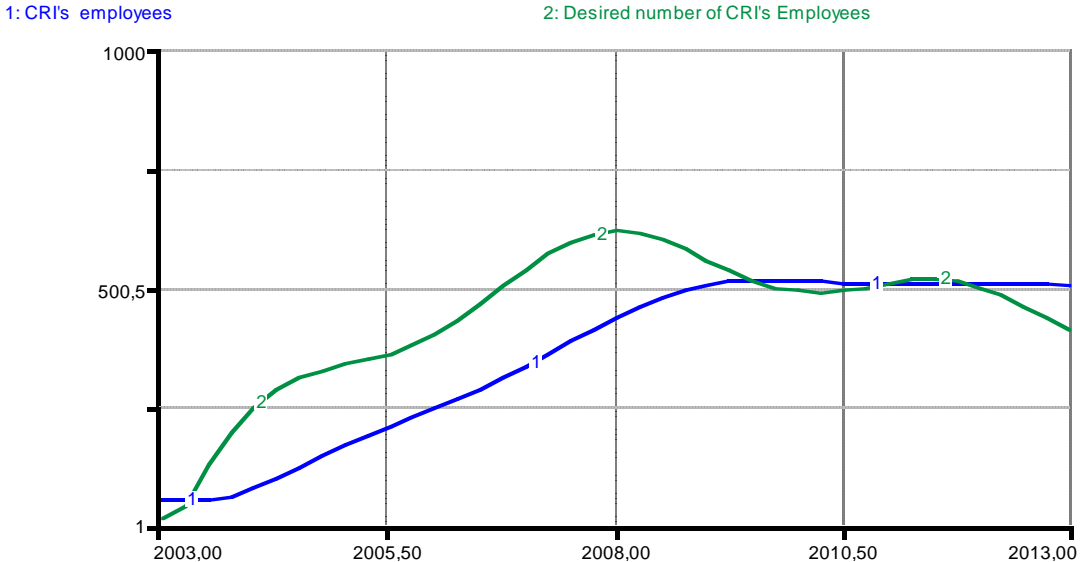
Figure 61: simulation of the CRIs employess
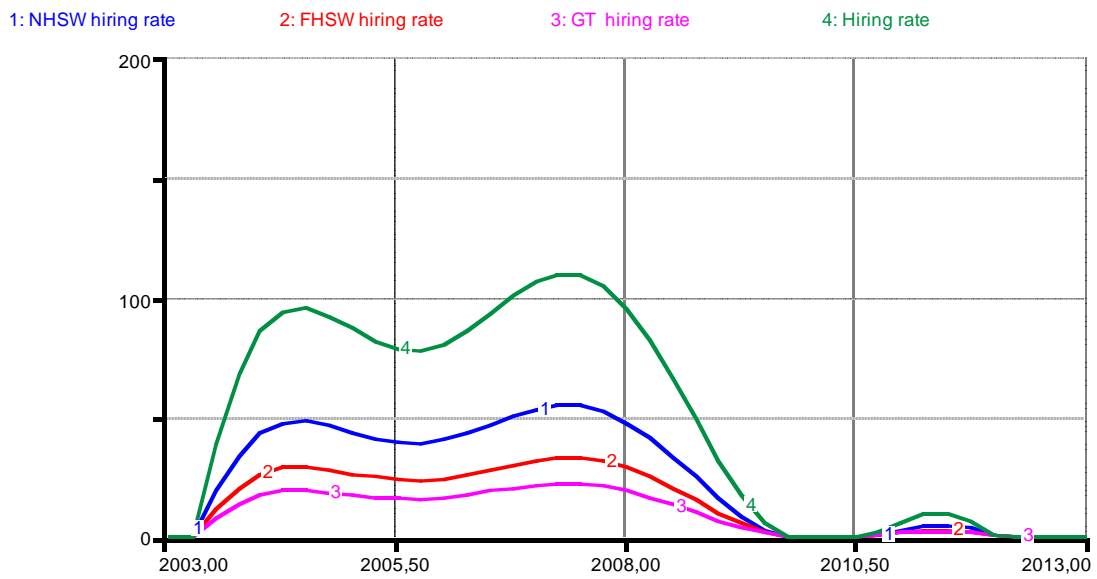
Figure 62: simulation of hiring rates

Finally, one most notice that there is not a mechanism for hiring GT given the great CRIs' moment experiencing a considerable growth of employees. One most evaluate if integrating GT to this inertia could be beneficial not only for the government and university, but also for industry.

Chapter IV:

Evaluating and purposing Policies

- DAMVAD stated in the last statistical report that one way to supply the need of high skilled labor force is by hiring Global Talent [2]. Should the government force Industry to hire only GT?
- Industry claims the university labors itself when bringing international students; University looks for its own interest [2, 3]. Should the government control the admission of international students?
- The Swedish government announced in 2011 that International students would be charged tuition at Swedish universities; this does not apply for EU-Residents [24, 25]. Should Norway implement the Swedish strategy?
- We have discussed that the cooperation between University and Industry in Norway has been gradually increasing when it comes to R&D. Some teaching and specific programs are stronger or have better results than others. But when it comes to meet the third university-industry mission, there are still many things to do. Should the government stimulate industry and university to include GT as a third mission? Industrial PhDs are coming more popular in Norway, Should the University and Industry reinforce their teaching by creating industrial programs for GT? Could the integration of GT to the Norwegian labor force be seen as crucial to activate the exponential growth of the expected university-Industry? How?

The purpose of this section is to find pros and coins of the above ideas. Using CLDs of the entire model, we will discuss and point out disconnections (lack of feedback or loops) on the entire model's CLD. Finally we will close loops using the suggested ideas, and simulate their behavior.

4.1 Evaluating the entire model using CLD diagrams:

In engineering control theory, it is impossible to stabilize unstable systems using open-loops, owing to systems uncertainties. Close-loops, on the other hand, provide current information and are more robust against sensitivity to external disturbances or changing parameters in the system itself [26]. Closing unstable open-loops modifies the natural dynamics of the system, leads to better control, and helps predicting its behavior [27]. Applying the feedback loop control theory is not new in management of organizations; human organizations exhibit much higher level of complexity than technological systems [28-30].

Figure 63 shows a cause and loop diagram (CLD), which summarizes the current relationship between the GT transition (blue arrows), university-industry collaboration (green arrows), and high skilled labor force (red arrows) in Norway. Although it is clear that the international students' admission depends on the university's desired capacity, this does not in any way is linked nor consider the fraction of employed GT, much less is related to university-industry collaboration.

The university-Industry cross-cooperation, on the other hand, does not consider global talent as one of the most important outcome of its collaboration. Figure 63 shows systems working independent to each other whose ideal performance has been so far away their own goals. *More often than we realize, systems cause their own crises, not external forces or individuals' mistakes* [Peter Senge, The Fifth Discipline, 1994]. The discussed policies stated on the "propose and research questions" part, of this section, seem all to be logic because they close some open-loops portrayed on figure 63. However, closing loops is not enough, because also creates short and long term effects on other sectors of the model; we must therefore analyze all possible pros and coins, and use operational questions for implementation planning, i.e. taking policy implementation seriously [31].
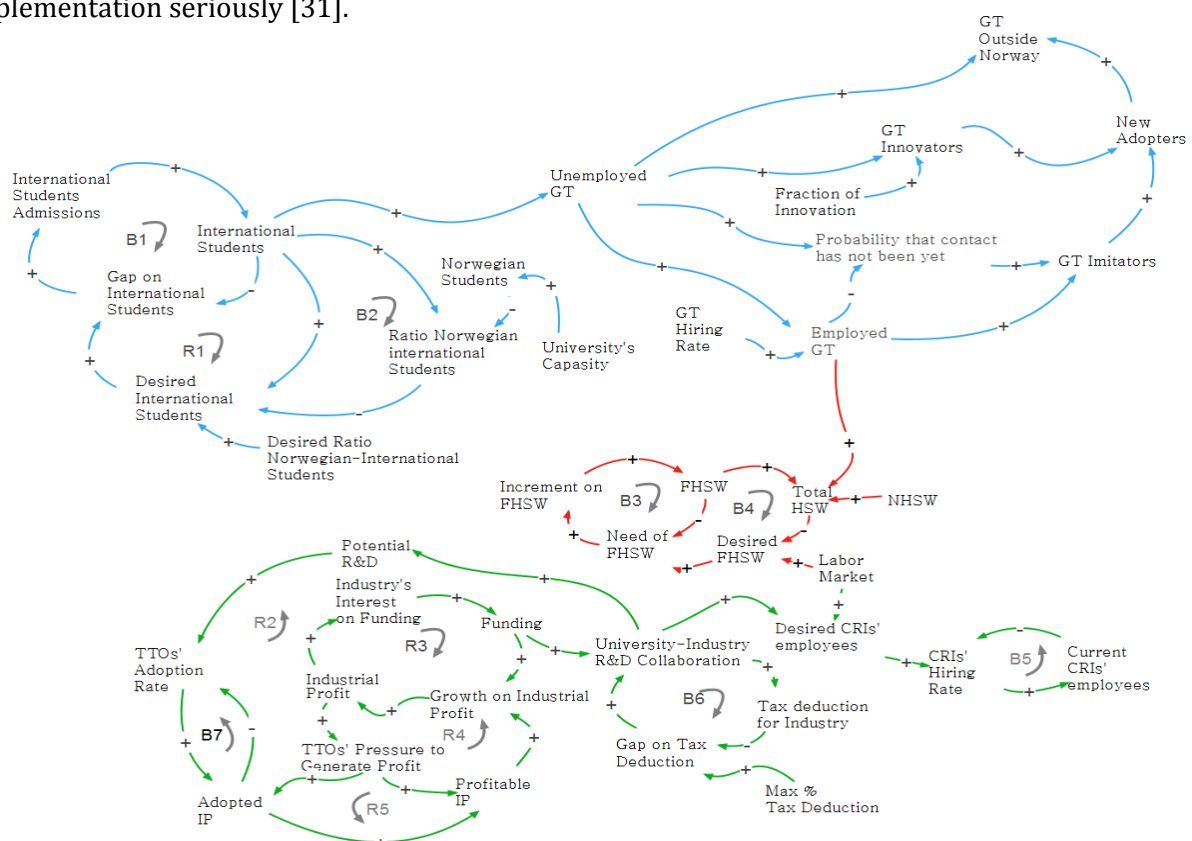

Figure 63: CLD of the Entire Dynamics of GT integration to Labor force and University-Industry cross-collaboration

4.2 Introducing University Fees:

The Swedish government announced in 2011 that International students would be charged tuition at Swedish universities; this did not apply for EU-Residents [24, 25]. Should Norway implement the Swedish strategy?

One must examine if the massive increment of international students arriving in Norway is a caused as response to the Swedish implemented policy on tuitions for International Students. According to the University World News, The number of international applicants fell dramatically in Sweden from 132,000 in 2010 to 15,000 in 2011; despite Swedish universities believe they are moving in the right direction or building up to recovery from the crash on international students, at a stroke, Non-EU students, the cost of fees for studying in Sweden became almost as going to British or American Universities [32]. American and British Universities are ahead of Europeans, including Sweden and Norway, according to several worldwide top university rankings.

Austria, Germany, and Finland could make the most of the Norwegian Implementation of charging non-EU students, because those countries still offer free higher education in Europe [33]. Charging International students in Norway does not facilitates the transition from testing parameters to testing new feedback structures as suggested in order to take implementation seriously [31]. Norway could pay an enormous short and long term cost by charging international students; among the five most common reasons for choosing Norway, international students stated: Non-tuition fees, according to DAMVAD's statistical report [1-2].

4.2.1 The simplest current model of the Norwegian University's Attractiveness:

Previously, we mentioned the five most common reasons of international students for choosing Norway to take higher education. According to DAMVAD's statistical Report [2], the fact that education is in English and free, are the first and second most common reason for choosing Norway respectively. "Norway is safe", "Jobs upon graduation", and "a degree from Norway will improve my career", are the other 3 reasons for coming to take a university program. Figure 64 portrays the simplest model of the Attractiveness of the Norwegian University; it is computed as the average the above reasons.
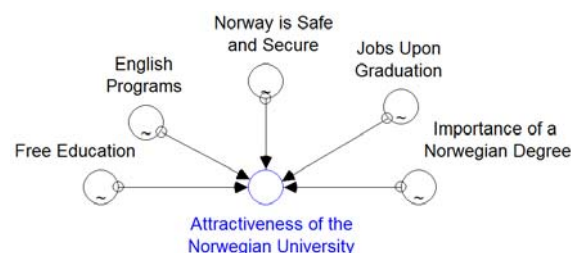
Figure 64: Attractiveness of the Norwegian University

A quick experiment is to set the English Programs as a graphical function which gradually increases from 0 to 0.5. More and more English programs are continuously being offer each year by Norwegian Universities. The Free Education is model is constant and set to 0.4; it is slightly less significant but the second most important reason for coming to Norway. Norway is secure and safe is set to 0.3 since it is the third most chosen option when evaluating Norway. Jobs upon

graduation are assumed to increase from 0 to 0.2, and the importance of a degree from Norway goes from 0 to 0.1.

4.2.2 Emulating the Swedish Case using the simplest model of the Norwegian Attractiveness:

Once we believe the simplest structure of the attractiveness of the Norwegian university is reliable, we move to the next step, what could be the best scenario of introducing fees for international students? Figure 65 shows the graphical function of tuitions. One must ignore the time axis since this is just an exemplification of what the effect of charging international students may be; we assume in our computation that from 2003 to 2008 non fees were introduced, but from 2008, International students are charged.
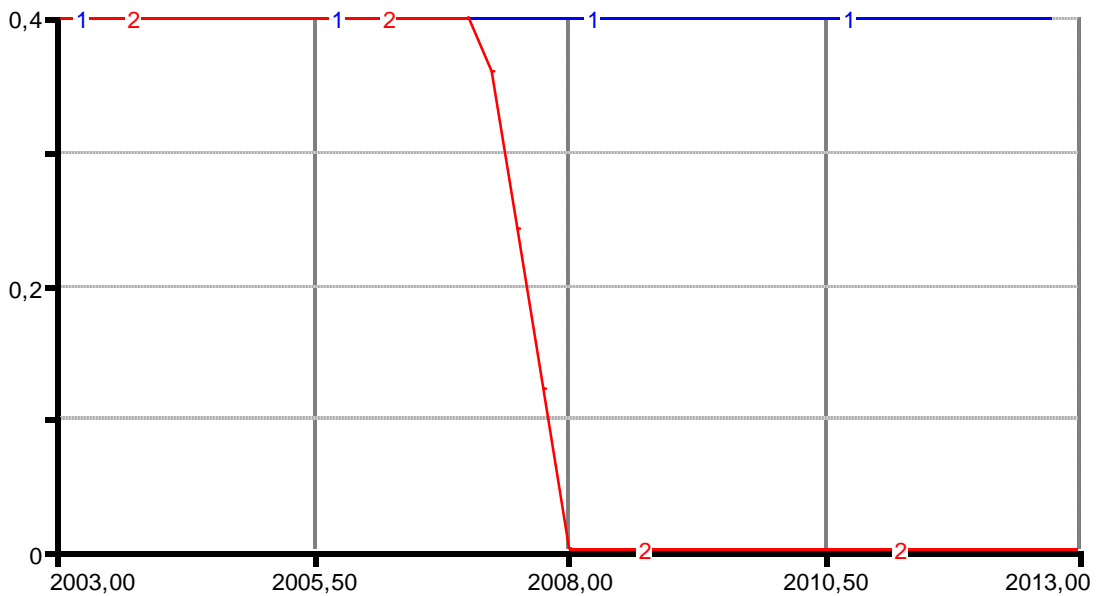
Figure 65: comparative function: 1) Non-Tuition Fees, 2) Tuitions from 2008.

Figure 66 portrays the response of the Norwegian University Attractiveness to the implementation of charging international students.

Figure 66: Response of the Norwegian University's Attractiveness: 1) Non-Tuition, 2) Tuitions from 2008

62

IT is observed that introducing fees dramatically decreases the Norwegian University's Attractiveness, just as the Swedish case: "The number of international applicants fell dramatically in Sweden from 132,000 in 2010 to 15,000 in 2011 [32]".Perhaps this model could have been used by the Swedish government and universities.

 The biggest mistake of the model on figure 64 is its structure, because it ignores the fact that having more international students increases popularity on international university rankings and consequently influences the last parameter "Degree in Norway will improve my career"; industry may love hiring international students who graduate from top worldwide universities. Moreover, the structure also ignores the fact that job opportunities fluctuates in Norway over the years as well in Europe.

Figure 67 shows more realistic consequences of introducing tuitions for international students on the attractiveness of the Norwegian University. Simulation is a comparative plot: 1) Non-tuitions, 2) Tuitions from 2007, 3)   tuitions also affecting the factor ""Degree in Norway will improve my career", and 4) introducing the job fluctuations to simulation 3.

Attractiveness of Norwegian University: 1 - 2 - 3 - 4 -
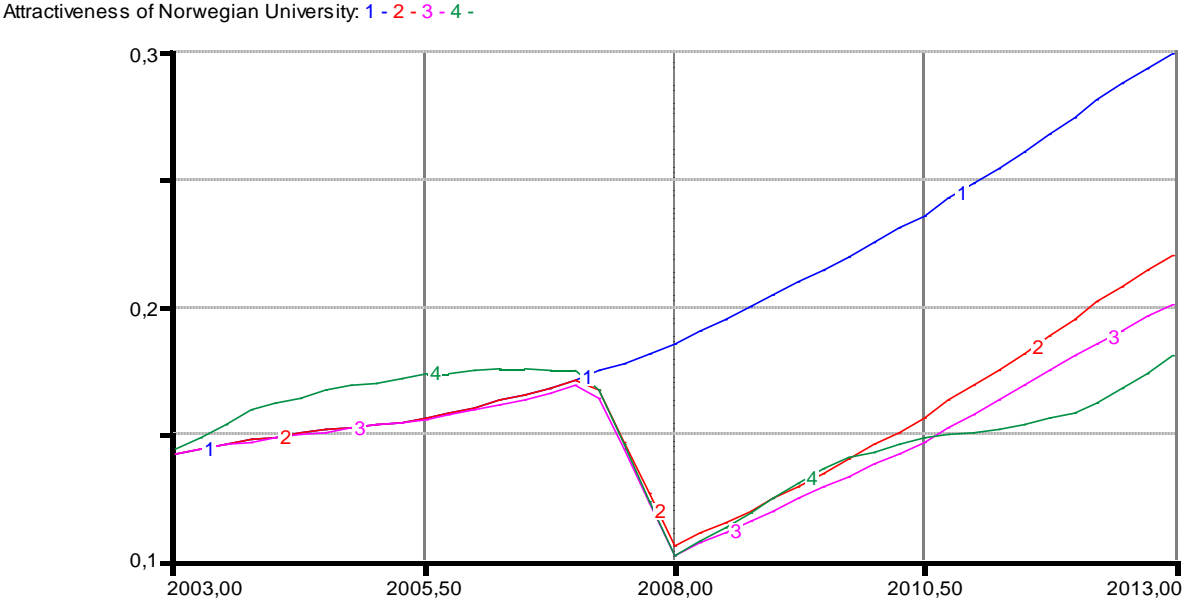
Figure 67: A comparative simulation of possible scenarios of charging international students.

The Swedish government and university could claim they look for quality rather than quantity, by offering scholarships to the best international students. But they may also forget that top worldwide universities also offer scholarships to the best international students [34]. Similarly, The Norwegian Government could spend a lot of the money earn by charging international when promoting their universities and grants outside Norway; the brightest students may prefer top universities. Norway has an enormous gap to compete with British or American universities according to international worldwide university rankings and projections indicate the trend of hiring International high skilled workers will remain [www.ssb.no].

4.3 Controlling University Admissions:

Industry claims the university labors itself when bringing international students; University looks for its own interest [2, 3]. Should the government control the admission of international students?

Figure 68 is a CLD of the dynamics of the Global Talent population from their admission to the university to their transition to the labor market. The green arrow indicated the suggested policy of controlling the international students' admission. As mentioned before, closing loops of unstable system move its behavior towards equilibrium. To test the proposed Idea, we have created the variable Ratio of GT outside Norway and GT employed as our reference to control the admissions
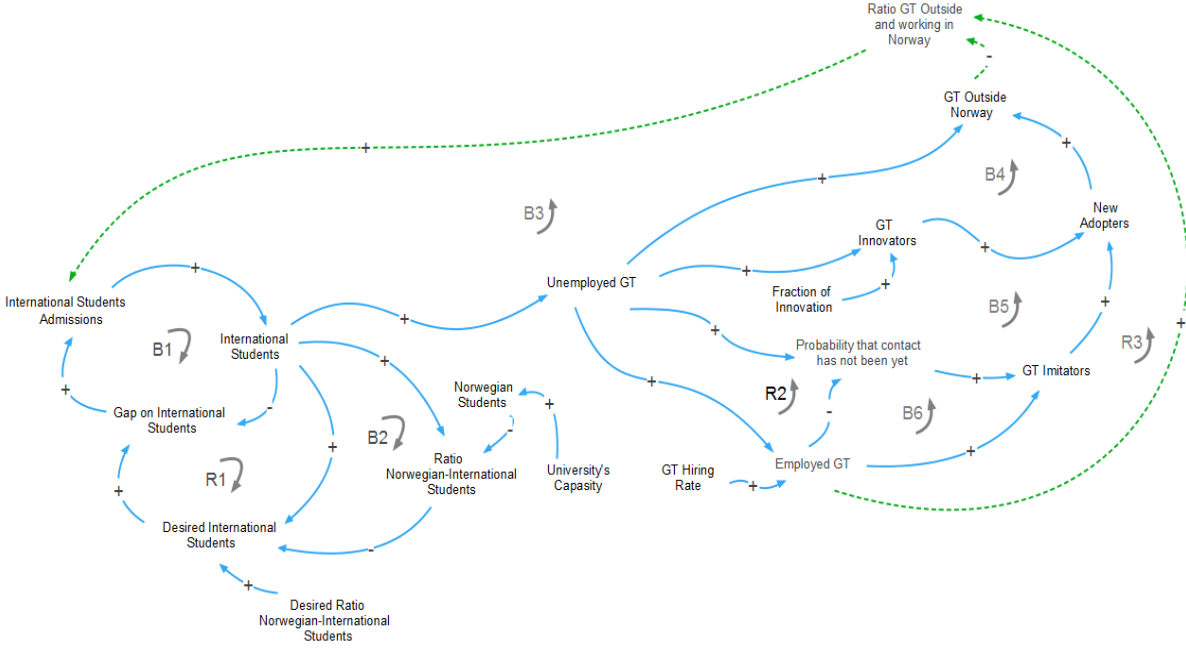
Figure 68: Policy CLD for controlling the Admissions of International Students

In Section 3.2.1, we introduced a model for estimating the University capacity in terms of Norwegian Students; we mentioned that a similar structure of figure 40 is used to compute the international student's admissions. The variable "Total Admissions", see figure 40, is computed using the model on figure 69 (Blue structure). A fraction of the Total Admission corresponds to Norwegian and International student's admission separately. The Total admission on the other hand depends on the University Desired and Current capacity as seen on figure 69; it is a goal seeking structure. The desire Capacity is given by the university and government needs, i.e. "Stretch factor of Desired University Capacity".

The current relationship is given by the next equation:

$$Desired\ Capacity = University\ Capacity * Strech\ Factor$$

The stretch factor was computed by optimizing its value to minimize the Euclidian distance between simulation and raw data (2003-2013). The best value corresponds to 1.038. It means the university is growing in yearly average factor of 1.038 according to the raw data.

Controlling University Admission **(POLICY's Structure)** is to decrease or increase this stretch factor as response to:

$$Divisor\ of\ Strech\ Factor = \frac{Ratio\ GT\ Employed\ and\ Emigrated}{Desired\ Ratio\ GT\ Employed\ and\ Emigrated}$$

Where:

$$Ratio\ GT\ Employed\ and\ Emigrated = \frac{GT\ Employed}{GT\ Outside\ Norway}$$
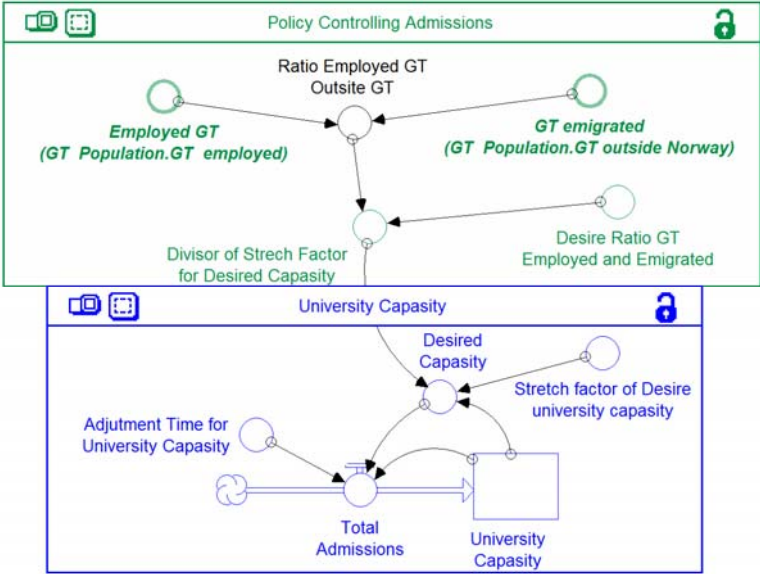
Figure 69: Blue indicates the current structure and green the added policy for controlling international student's admissions.

In other words, the policy consists in reducing the growth of the university admissions which consequently reduces the entrance of international students. In order to decide whether reducing the admission for the next academic year or nor, depends on the ratio between the stock value of the GT which are already outside and the stock value of those who are already working in Norway. We know that about 60% of GT from 2003 to 2010 are already back at home, and only about 40% remains in Norway but not necessarily working, therefore we create an auxiliary ratio called the desired ratio between GT employed and Emigrated. A high value will result on a more aggressive response or policy while a small value would be less harmful. In our computation this value corresponds to 1.2 which lies in the middle.

Figure 70 and 71 shows the pros of implementing such program. The plots computes and compare the projections of the current dynamic (Blue line), and when including the policy (Red line).

University capasity.Ratio Employed GT Outsite GT: 1 - 2 -
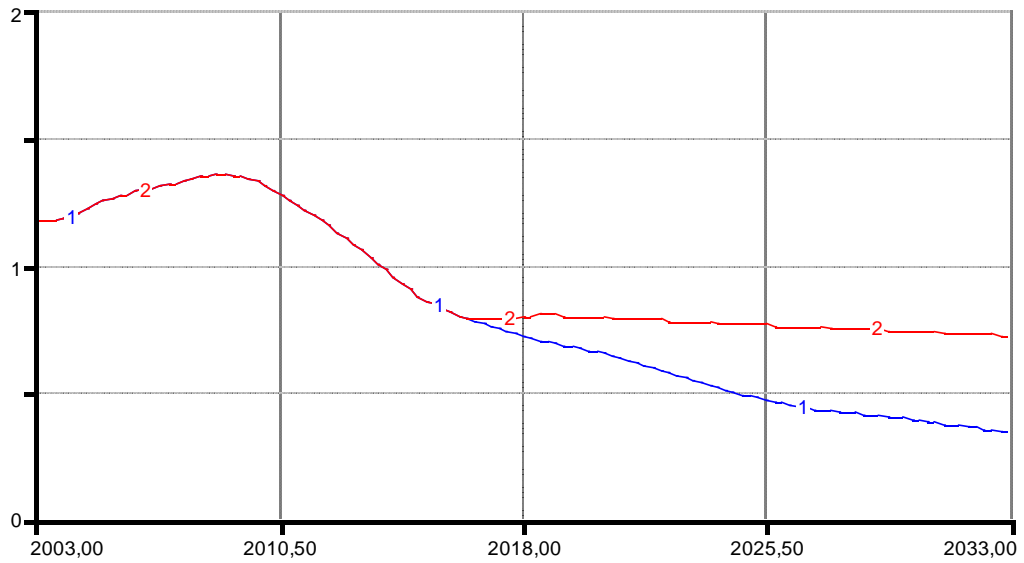
Figure 70: Ratio Employed GT- GT outside Norway. 1) Current Dynamics and its projection (Blue); 2) Policy action (red)

By inspecting the time axis we could infer the policy is computed to take action from 2014 in both graphs, see figure 70 and 71. The Gap between the GT outside Norway and those who are working in Norway is reduced using the suggested policy. Less International students are accepted year by year increasing the possibilities for those who are still in the country to get a professional job. Consequently the number of global talent outside Norway is dramatically reduced.

GT Population.GT outside Norway: 1 - 2 -
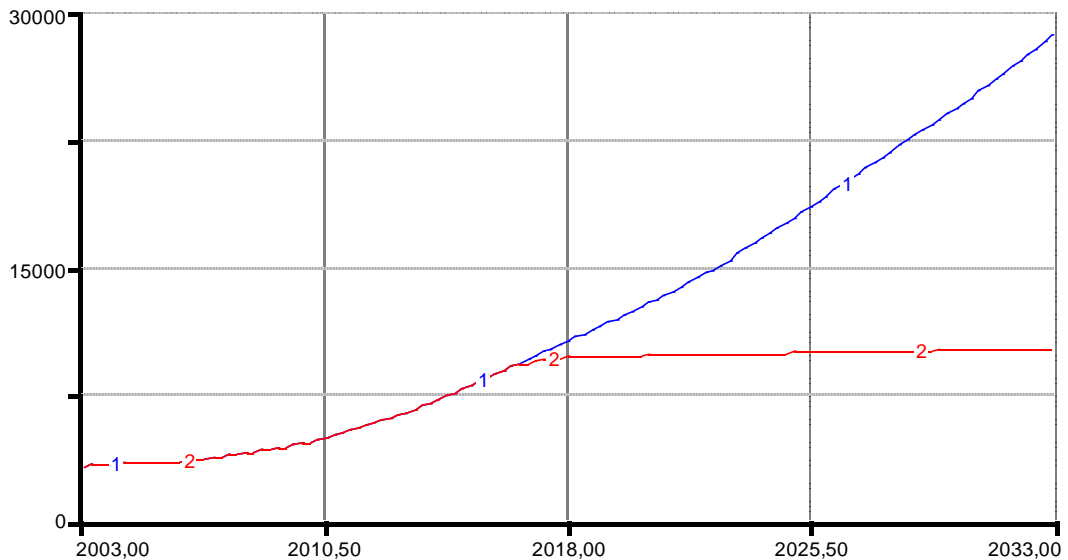
Figure 71: GT outside Norway. 1) Current dynamics and its projection, 2) Policy action.

But what are the possible coins of implanting this policy? We have to inspect other modules in our entire model, for instance what happen to the university capacity, does it remain growing? If

we block the entrance of International Students, what does occur to the need of labor force in the country? Perhaps this is one of the advantages of using system dynamics; it help us to have not only a systematic picture, but also a global vision, i.e. a change in a subsystem may affect another and consequently creates worse or better results which are easily observed suing SD.

Figure 72 portrays the effect of the policy for controlling admission on the university capacity, see the red line. From 2014 the university stops growing, and consequently the lack of high skilled labor force increase, see figure 72. We solve the GT dynamic problem but increase the need of labor force.

University capasity.University Capacity: 1 - 2 -
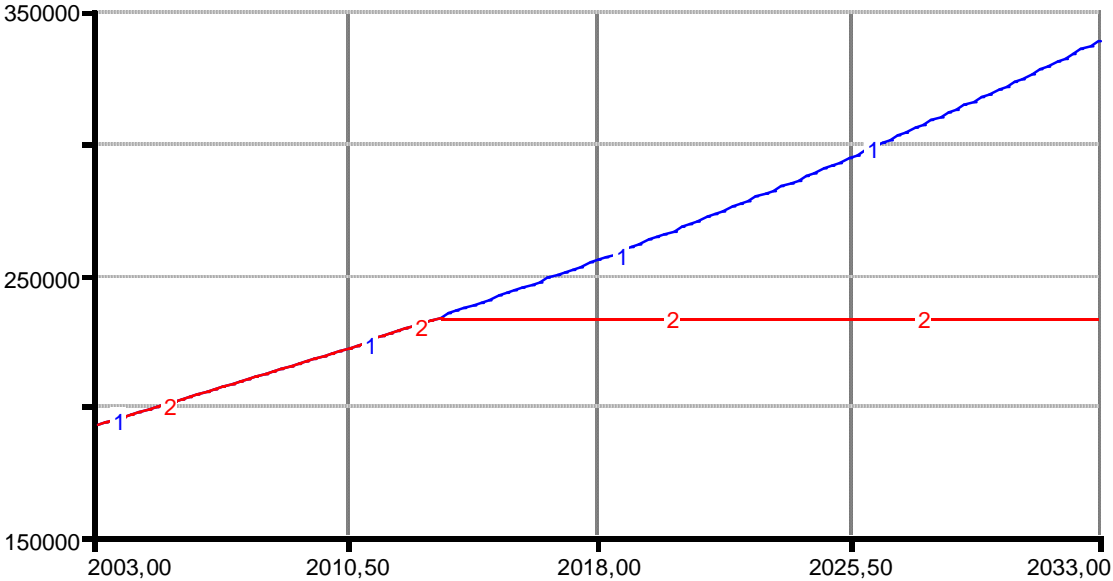
Figure 72: University Capacity. 1) Current Dynamics and its projection. 2) The effect of the suggested policy.

Labor Force.Lack of Norwegian High Skilled Workers: 1 - 2 -
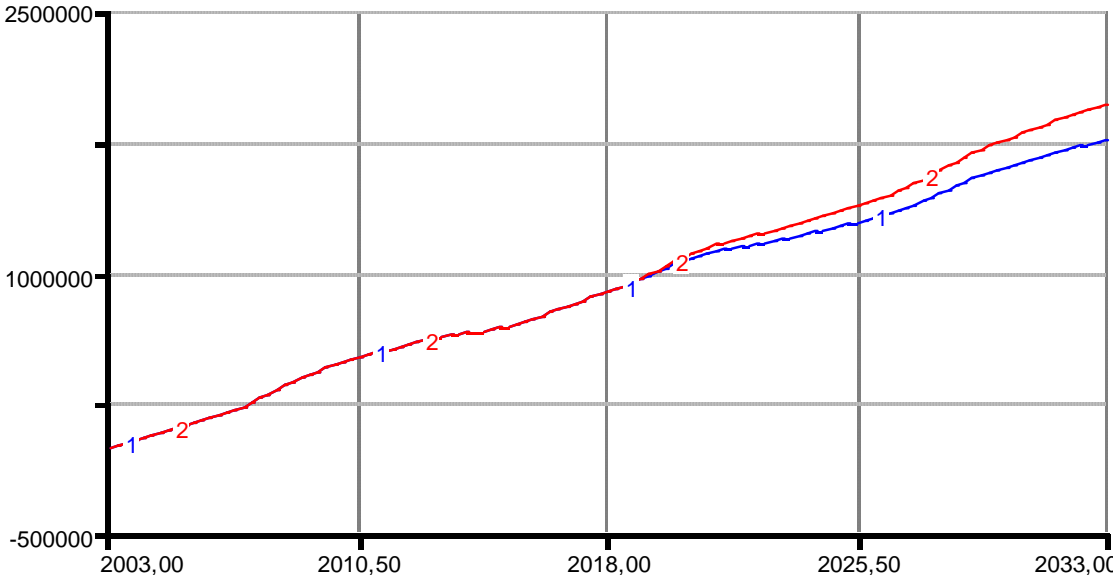
Figure 73: Need of High Skilled labor Force in Norway. 1) Current Dynamics and its projection. 2) The effect of the suggested policy.

4.4 Adding DAMVADS's policy:

DAMVAD stated in the last statistical report that one way to supply the need of high skilled labor force is by hiring Global Talent [2]. Should the government force Industry to hire only GT? Figure 74 shows a comparative graph of the GT hiring rate. It is observed that despite controlling university admissions solves the number of emigrated GT; this policy does not affect the GT hiring rate (Red line). On the other hand, if the government reduces the entrance of Foreign High Skilled Workers (FHSW) in order to prioritize GT there would be a notorious favorable change on the number of GT getting a job in Norway each year, see figure 74.

GT Hiring Rate.Annual Jobs taken by GT: 1 - 2 - 3 -
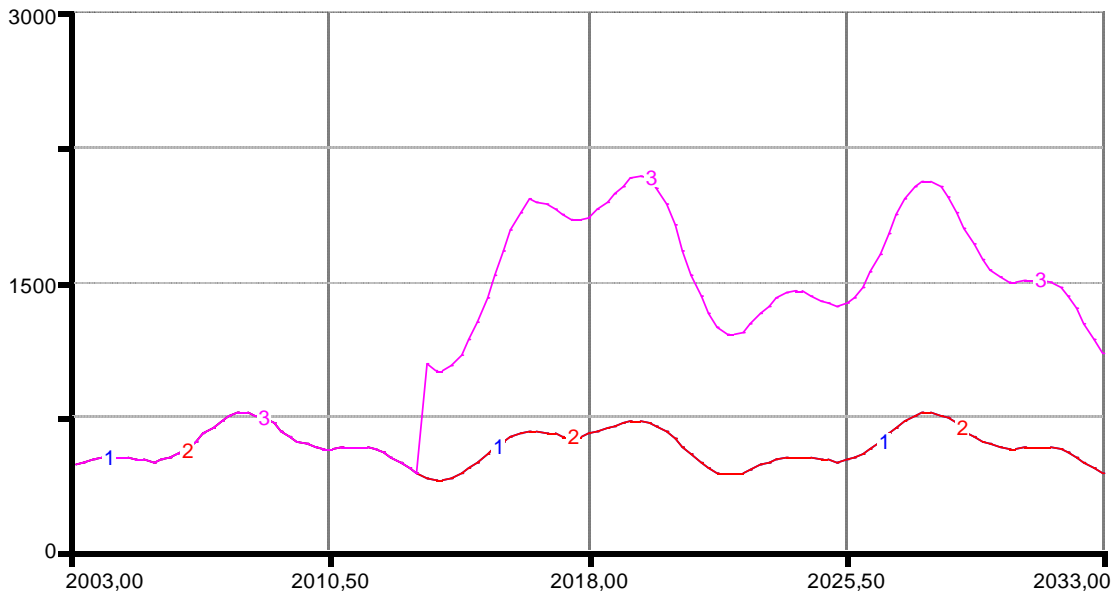
Figure 74: GT Hiring rate. 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion

Figure 75, shows a CLD diagram of the Global talent and Labor force models, blue and red lines respectively. The green line (policy) is a reinforcing loop which explains the increment of the plot 3 in figure 74.
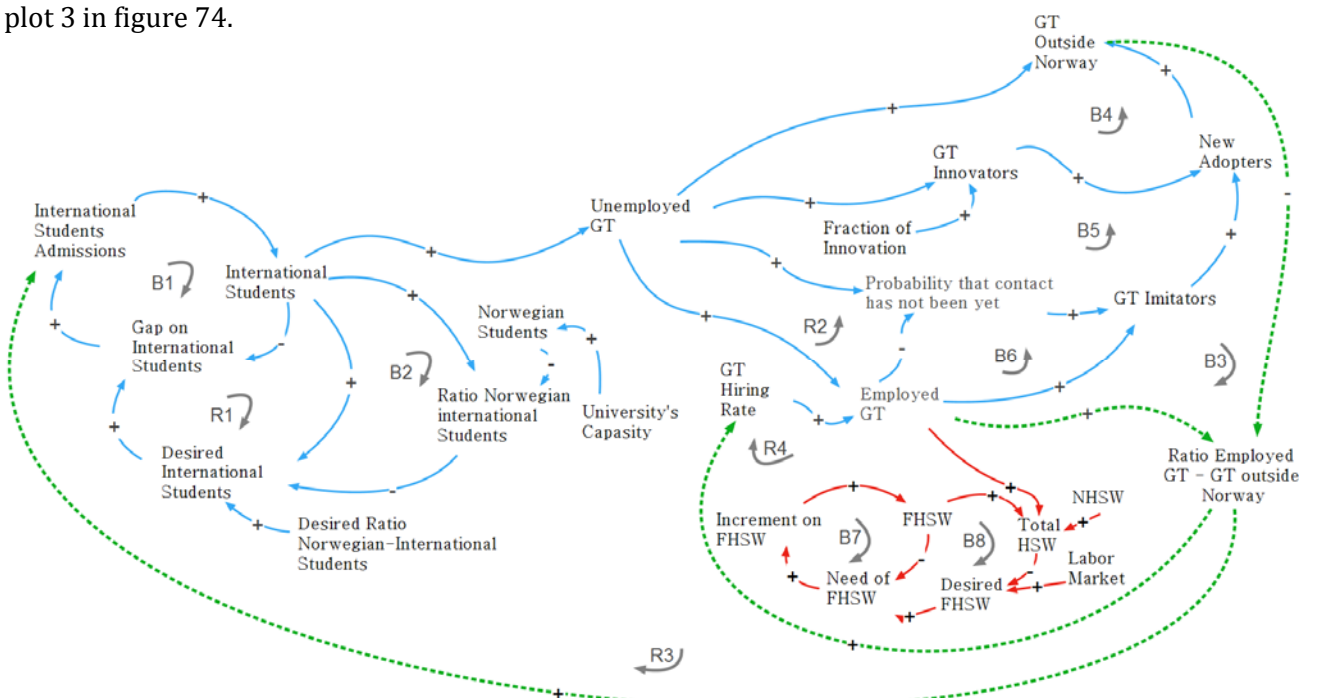
Figure 75: CLD of the current GT and Labor Force dynamics (Blue and Red lines) and policy (Green line)

We next transform the policy on figure 75 into stocks and flows, referring sections 2.1, 2.2, and 2.4. We collect the relevant structure where DAMVAD's policy feeds. See Figure 76.
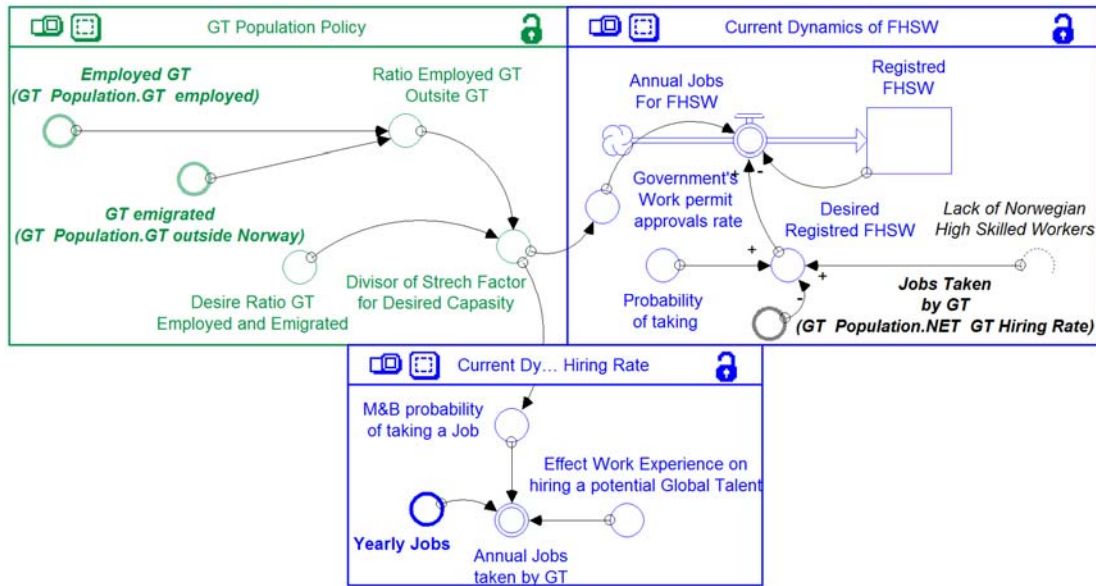
Figure 76: Controlling meeting the need of labor force by hiring GT. Current structure (Blue), Policy (Green)

Basically, the policy suggests that in order to meet the need of labor force, industry should prioritize GT for any job vacancy. Industry would not easily accept this policy for their own reasons; the government could force industry by neglecting their work permit for FHSW's applications. The consequences on the GT hiring rate were portrayed on figure 74, where a notorious increment is found when implementing such policy, leading to a decrement on emigrated GT, see figure 77.

University capasity.Ratio Employed GT Outsite GT: 1 - 2 - 3 -
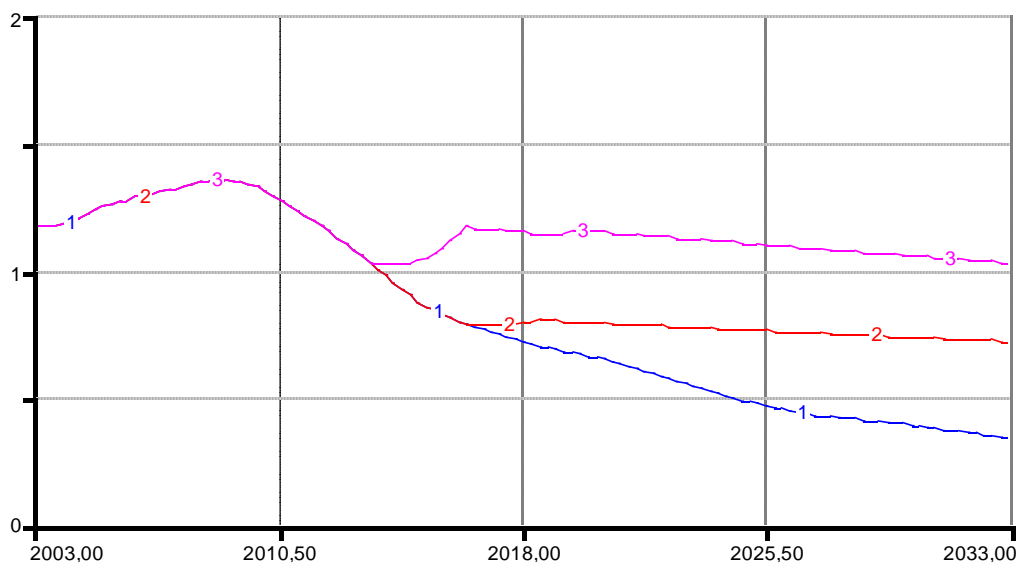
Figure 77: Ratio Employed GT-GT outside Norway. 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion

Another advantage of adding DAMVAD's suggestion, compared with the policy of controlling admissions alone, is that the university desired capacity is improved, i.e. the university experiences also a slightly significant growth. See figure 78.

University capasity.Desired Capacity: 1 - 2 - 3 -
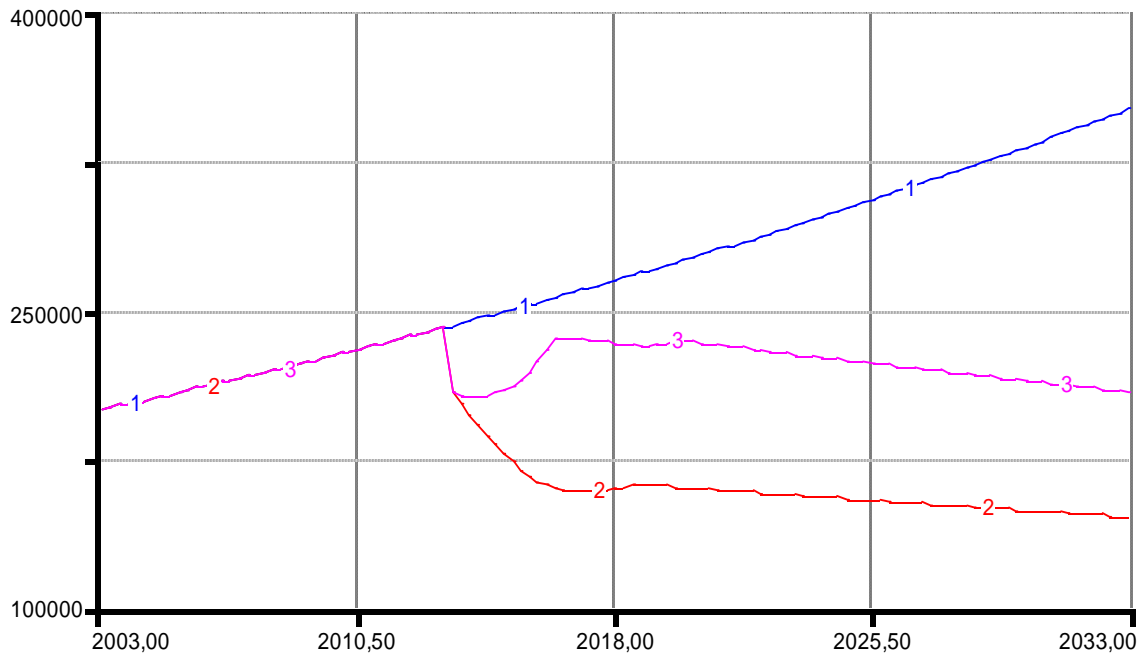
Figure 78: Desired University Capacity. 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion

We must be aware that increasing the hiring rate of global talent does not necessarily means we solve the need of labor with high skills. Figure 79 proofs that DAMVAD's suggestion will not solve this issue.

Labor Force.Lack of Norwegian High Skilled Workers: 1 - 2 - 3 -
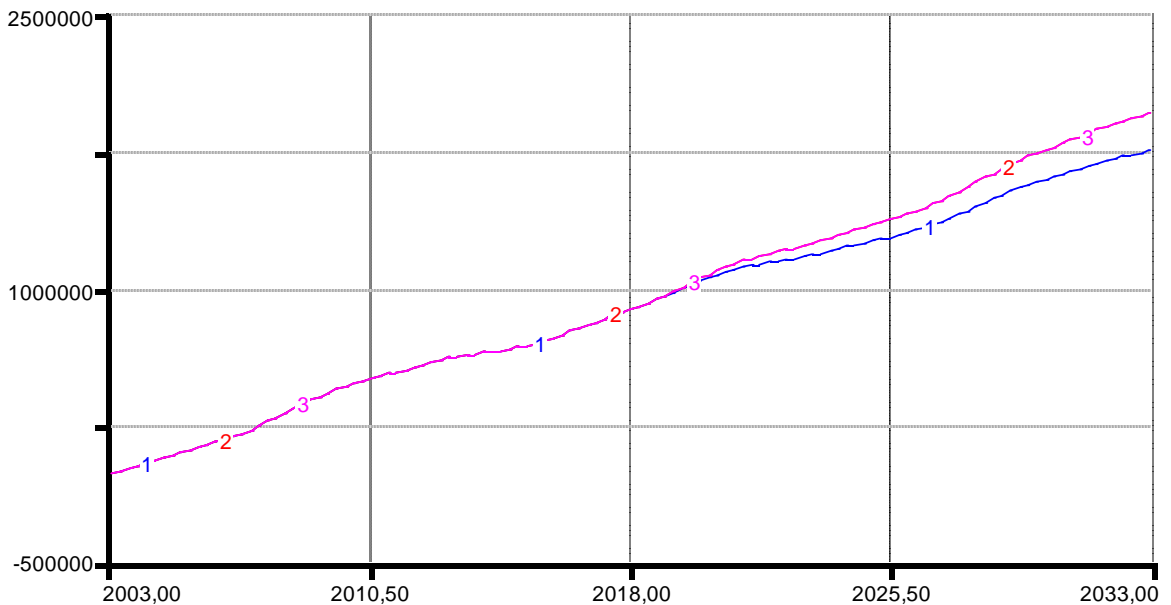
Figure 79: Need of Labor Force with High Skills in Norway. 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion

A possible playback of this this policy is the fact the Norwegian Industry lack high skilled workers with seniority level, i.e. with more than 5 years of experience. Most of the job vacancies posted on the biggest job search engines in Norway clearly state for more than 3 year of work experience [35, 36].

Unfortunately meeting the need of such experienced labor force by hiring GT is probably not the optimal solution; Training newly graduates often requires the help and mentoring of experienced employees. Senior employees typically spend a fraction of their job time when solving questions of inexperienced juniors and consequently impact the productivity [37].

Sterman's "Business Dynamics" book provides a SFD model for rookies and experienced employees called *"A two-level promotion chain to explore worker training"* [37]. Figure 80 contains a similar model using the Employed GT as juniors and FHSW as senior; we aim to illustrate possible playbacks of forcing industry to hire GT instead of High Skilled workers, assuming industry only hires FHSW with a certain seniority level.

$$Effective\ Seniors = MAX\ (0, \quad FHSW - Time\ spent\ training\ Juniors)$$

$$Effective\ Juniors = Average\ Junior\ Productivity * Employed\ GT$$

$$Time\ spent\ training\ Juniors = Employed\ GT * Fraction\ of\ time\ spent\ by\ Seniors$$

$$Productivity = \frac{(\ Effective\ Seniors + Effective\ Juniors)}{Total\ Workers = Employed\ GT + FHSW}$$
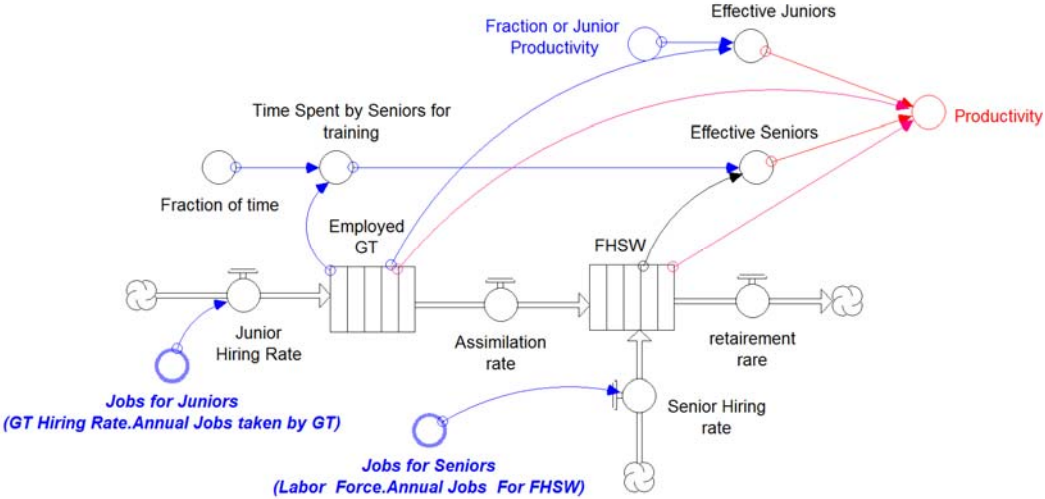
Figure 80: Measuring the productivity of High Skilled Labor force to evaluate DAMVAD's policy

The annual jobs for GT and FHSW are used as the hiring rate of both: Junior and seniors, because is computed using the estimated labor market in Norway and indirectly affected by the suggested policies.

Figure 81 shows the results when simulating and measuring the model portrayed on figure 80. One could immediately infer that productivity would dramatically fall down by analyzing the equation previously developed. Conversely, result indicates there is a slightly decrement on the labor productivity which could be neglected. Productivity insignificantly decrements because there are 7 times more FHSW than employed GT [2], so meeting the demand of skilled labor hiring GT is not a bad idea at all; they represent a minority. Even though, Industry hires all GT, it would not limit industry to bring foreign experienced HSW; the Norwegian labor need is massive compare to the GT population.
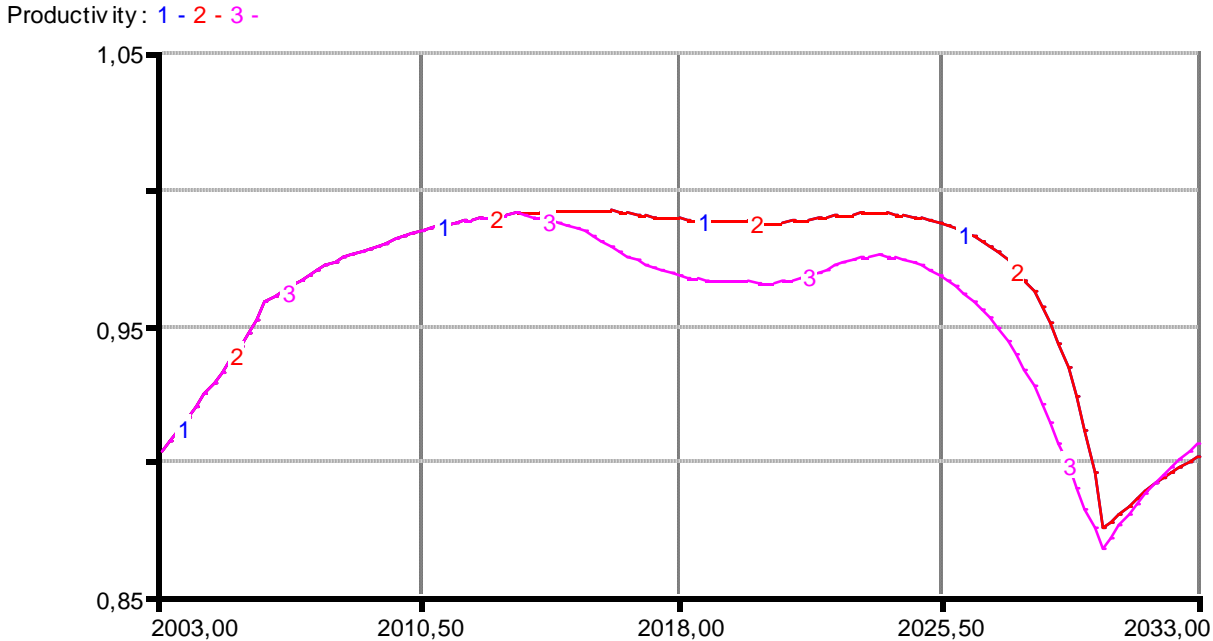
Figure 81: Labor Productivity of the Norwegian Industry. 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion

4.5 University-Industry Collaboration by including GT as part of their third mission.

The term "knowledge-based economy" came from the recognition of knowledge as an important productivity engine for economic growth; knowledge embodied in human beings (Human Capital) and in technology, has been central to economic development [38]. However measuring the performance of knowledge-based economy may pose a great challenge because knowledge itself is particularly difficult to quantify and price; an unknown proportion of knowledge is implicit, encrypted and stockpiled only in the minds of individuals.

Despite, there is still the need to find the proper indicators of growth in knowledge base itself [10], the OECD's principal standardized indicators are: 1) expenditure on R&D, 2) employment of engineers and technical personnel, 3) patents, and 4) international balances of payment for technology [10]. These indicators are very similar to the Norwegian University-Industry cross-cooperation indicators which are: 1) R&D, 2) teaching and specific programs: CRIs, 3) a third mission: patents. Is the Norwegian government reinforcing its knowledge-based economy? The government has created several programs to foment and help University-Industry cooperation [7, 8]. The flows and relationships among industry, government and academia in the development of science and technology, are important economic elements of the knowledge-based innovation model [38].

In this section we propone an innovative framework founded on the concept of knowledge-based economy to benefit not only industry, government, and university, but also to make the best of students taking higher education in Norway including global talent (internationals).

Facts in Norway:

1. In Norway, any Norwegian citizen taking a university degree can be granted to a credit loan "lanekassen". The obtained credit could be up to 48.925,00 NOK per semester [39]. A large fraction of university students take this credit opportunity not only because its low interest rate; there a several advantage when paying back the loan after graduation.

2. International students who come to take higher education have to have the same amount of money per semester in order to be entitling to a study permit [4]. In fact this amount is the average living expenses for any university student in Norway.

3. The minimum salary per hour in Norway is about 174, 10 NOK for skilled workers. This is about 313.380 NOK per year. 19% of the salary most be added in order to compute how much a given company most pay for one employee. The minimum outlay per skilled worked is about 372.990NOK per year (tax included).

4. According to DAMVADS statistical report, several students would like to have a part-time-job to help their living expenses, just a fraction of them are able to get a part-time, and few students of those who get a part-time job get a job related to their educational program [2].

5. Full-time Master program are two years in Norway [41].

Legal Advised from UDI:
We would like to refer our own investigation about immigration rules. We sent an email to UDI (Norwegian Directive of Immigration). The email encoded a piece of our strategy for reinforcing University-Industry integrating GT and if is found on **appendix C**.

We wrote to UDI as a start-up company which is interested on investing on its own personnel. We asked UDI about the possibilities for bringing and hiring two engineers from abroad to Norway. However what make special to our enquiry is that these engineers would only be part-time employed because they will be enrolled at NTNU (Norwegian University of Science and Technology) in a two year master program which is highly relevant for our research line.

UDI was aware that our case was unique and that we basically wanted to invest on our future personal. International students must show about ninety seven thousand Norwegian coroner, and therefore we requested about the possibilities for our two future engineers to apply students instead of workers; they will only have a halve-time job. The students (our engineers) would show a job contract instead of the required money to be granted a student-visa.

Surprisingly UDI came with a detailed email, where in conclusion, our company could support the two engineers to apply as student at NTNU showing a contract that specified the salary per month. The UDI officer also stated that the company would have to pay a bit more, twenty thousand, due to taxation. This means that we would have to pay the students a yearly amount of about hundred and twenty thousand Norwegian coroner (see appendix C).

Our suggested policy program:

As seen on figure 68, Norway lack a dynamic structure not only that control admission to university and work permit of high skilled workers to make the most of GT as proposed on sections 4.5 and 4.6, but also that integrates the University-Industry network. The two previous policies are negative feedback controlling population towards a desired goal; ratio employed GT and GT outside Norway.
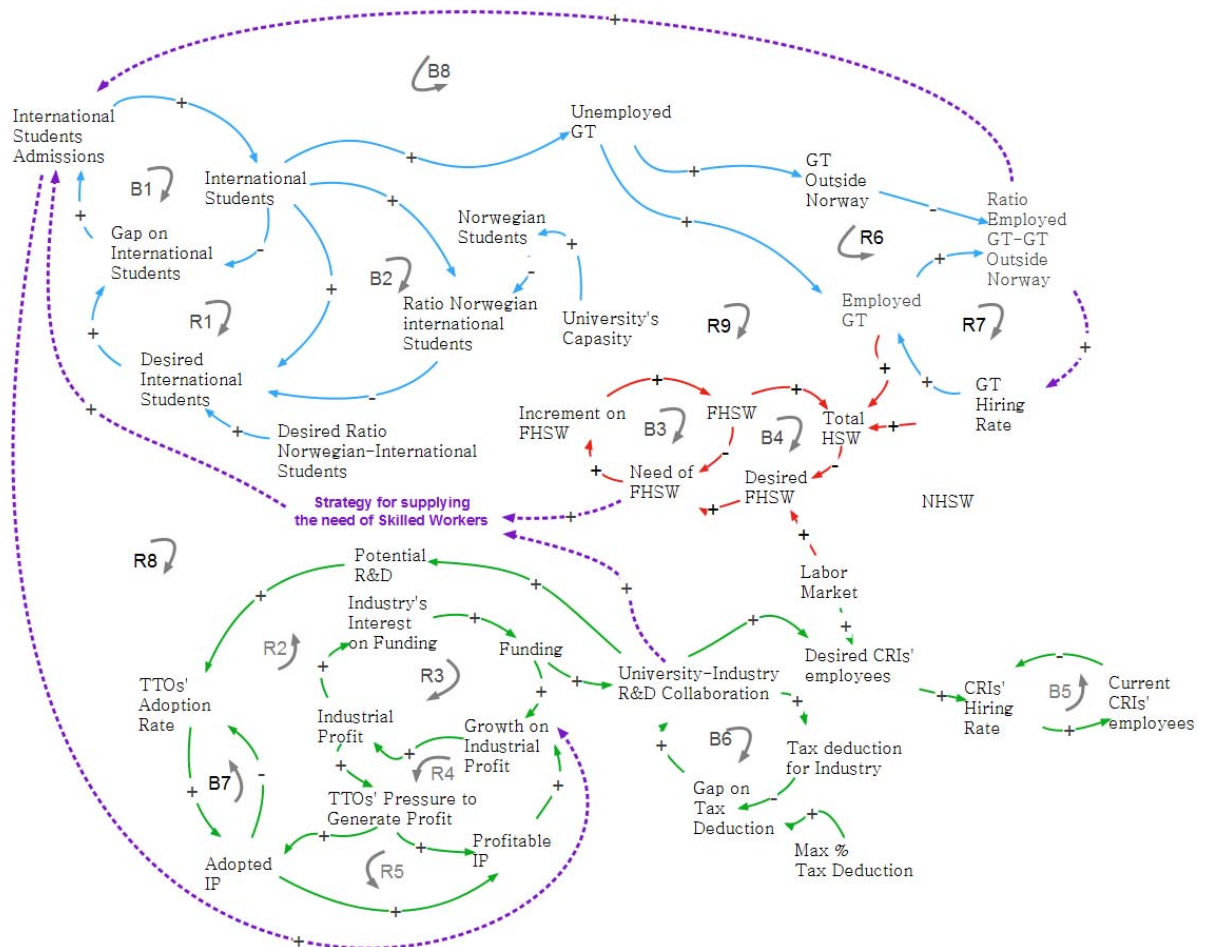

Figure 82: Reinforcing the University-Industry cooperation by integrating GT as part of their third mission

We concluded that when combining DAMVAD's suggestion of meeting the need of labor force by hiring global talent, and controlling university admissions of international students, there is an increment on the ratio employed GT-to-GT outside Norway, i.e., more job opportunities for GT. Figure 82 shows that we keep those suggestion but propone to reinforce the desired skilled workers population, university admission, and increment the university-industry cross-cooperation. See the purple dashed arrows on figure 82.

The cause and loop diagram suggest to strength the number of university admissions as long as the university-industry cooperation growths and vice versa. ***Does it solve the problem of increasing the hiring rate of GT and supply workers to the labor market?*** We believe creating Industrial university programs, masters and bachelors, would increase the Industry's profit, consequently increase university-industry collaboration, and finally this may be seen as the basis of knowledge based economy.

The main difference to the industrial PhD programs, created by the CRIs, is that instead money or founding comes from the CRI any company, and especially start-ups, could invest on what they need to see as future human resource. The university does not necessarily need to spend a lot of time on redesigning vocational programs to fit the industry need. In fact, Universities could just continue with the exiting degree programs, and industry could support part-time (International Students) workers which are enrolled on a degree that matches their necessity.

Who does make the most of the suggested policy?

1. Students: instead of paying a credit loan and their interest for several years after graduation, "lanekassen" in case of Norwegian citizens, or private loan for international students, the students are offered a part-time job within their professional field, additionally they are acquiring an invaluable work experience, just after graduation they could almost be a senior engineer for instant, in case the university consider to extend master program to 3 year within this industrial focus. The unbelievable here is: "they do not have to pay any money back for such program"; they are paid for halve-time working (50%) at the industry. **Keywords:** Work Experience, part-time job, university degree, no cost.

2. Industry: A full-time worker with non-professional experience normally would cost to the industry about 372.990NOK per year (tax included), but having two halve-time workers taking the industrial program would cost about 240.000 NOK per year. Industry is making profit of such program. **Keywords:** experienced workers, profit.

3. University: Universities could dramatically increase popularity, with intangible benefits of such industrial programs. Top student might like to have to take further education due to the described advantages.

4. Government: Norway will be seen as an innovator because in state of charging international students, they a players reinvesting resources to create more resources not only monetary but also human knowledge. A real Knowledge-based economy.

5. Some other facts: If the government for instance would allow using the taxes that companies would pay when supporting students, about 20.000,00, and give it to the university, university could increase human resources and increase their staff per students which according to rankings in Norway is low compared to other worldwide universities. Or even though investing the taxes on Norwegian courses. All students in industrial program must compulsory take slow progress Norwegian course and pass at least an intermediate level. This will facilitate their integration to Norway and therefore cultural adaptation.

Structure of the Policy:

Industrial Programs are designed created to supply the need of skilled workers. If considering, for example, an international student who has already taken a bachelor degree as a potential Junior employee, The Industrial program would allow to the "Industrial Student" to develop a valuable work experience while earning a further Education in his/her own work sector. In addition, the admission rate of industrial programs is a delay function of the Annual needs of workers in the country time a fraction that both university and industry desired that those industrial student supply workers to their need. Figure 83 portrays a stock and flow diagram of the Industrial Students (Workers) transition from Junior to Senior.
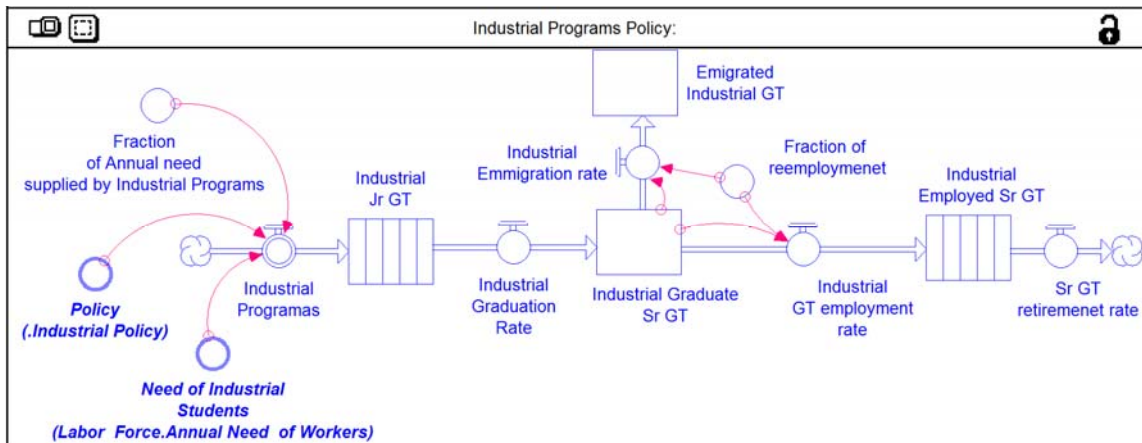
Figure 83: Stock and Flow Diagram of the Industrial Programs for GT

Figure 84 shows that Industrial programs do not aim to completely substitute the traditional university programs, but traditional university programs should remain government by the previously described policies. Industrial Programs also aim to increase University-Industry.
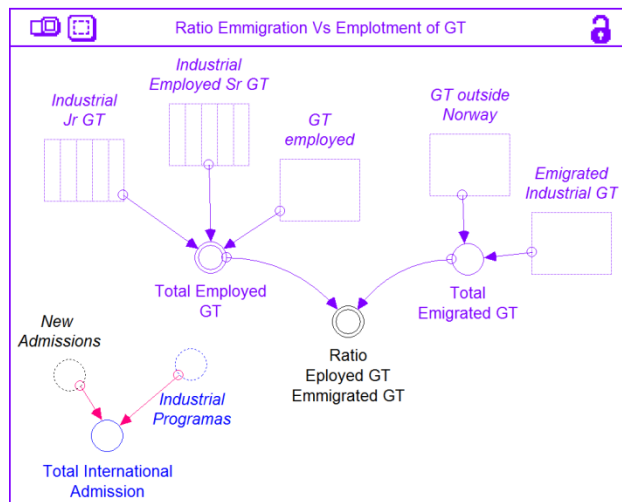
Figure 84: Ratio Employed GT-to-Emigrated GT

76

Additionally, Norwegian Students should also have the possibility to earn work experience while taking further education and having none-loans; equal opportunities.
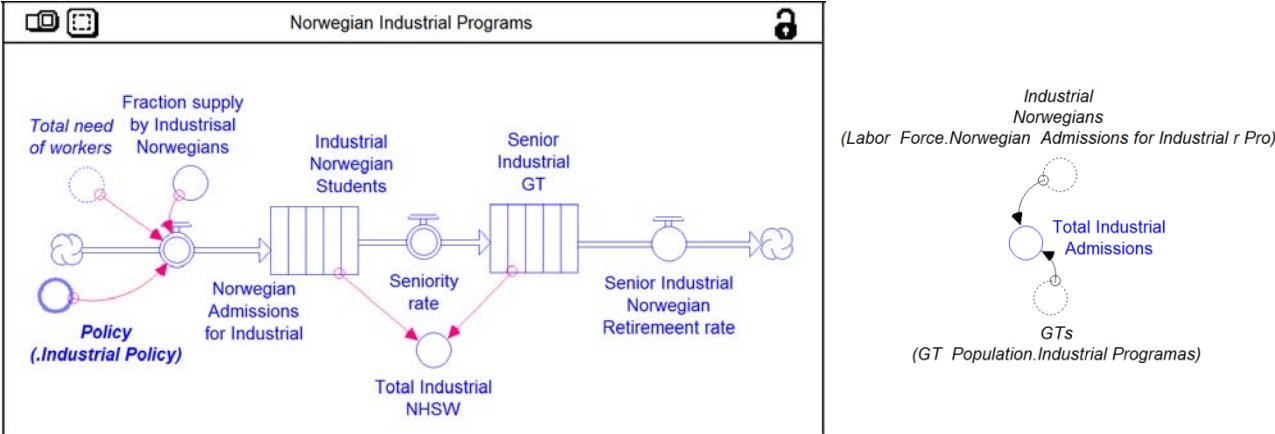
Figure 85: Industrial Programs for Norwegian Students. Total Industrial Programs Admissions

Industry and universities can benefit from such industrial program. The annual profit of industry and university are:

1. $Annual\ Industry\ Profit =$
   $0.5 * Total\ Admissions * (Fulltime\ Salary -$
   $Industrial\ Salary\ of\ two\ halvTime\ Students)$
2. $Annual\ Industry\ Profit = Total\ Admissions * 20.000,00\ NOK$

A full time employee could be replacing by two halve time employees within the industrial program. The government could decide that instead of charging taxes, about 20.000,00 NOK per each student to the industry, this amount of money could be given to the University as free budget or profit. Figure 86 contains the stock and flow diagram for computing the profit for both: University and Industry.
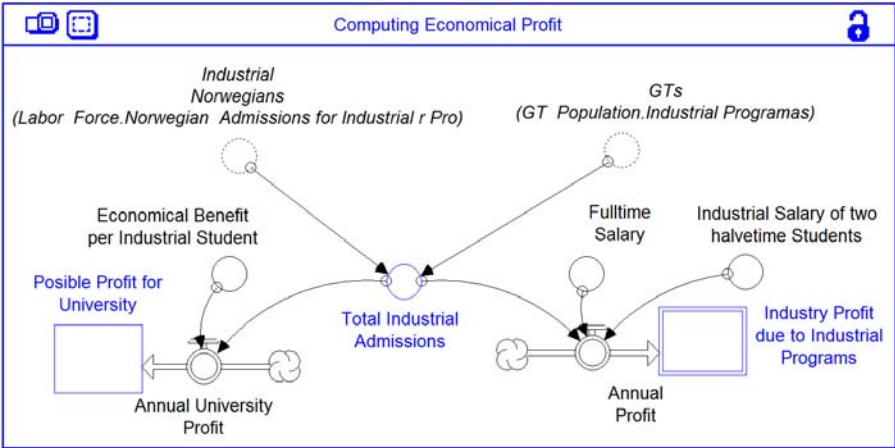
Figure 86: Measuring Economical profit for both: University and Industry separately

The monetary benefit must not be seen as the most positive aspect of the industrial University Programs. The reinforcement of the university-Industry collaboration must be emphasized, and the government should see industrial programs as a facilitator tool for helping foreign workers to get used to the Norwegian working environment and culture while increasing scientific knowledge. University could also spend part of its profit to create more Norwegian language

courses. Additionally and perhaps, Industrial University Programs could let the government to invest the money, which originally is planned to support Norwegian students (Lånekasse), in research and innovation. On section 3.4 we developed a model to measure the current university-industry cross-collaboration; the model can be observed on figures 53 and 57.

Figure 87 portrays how the diagram on figure 53 and 57 are complemented by the effect of Industrial University Programs' profit. Originally the industry profit was measured by the amount of obtained funding fir R&D plus the profit due to patenting. Figure 87 add the profit due to the industrial programs to the flow: Increment on Profit.
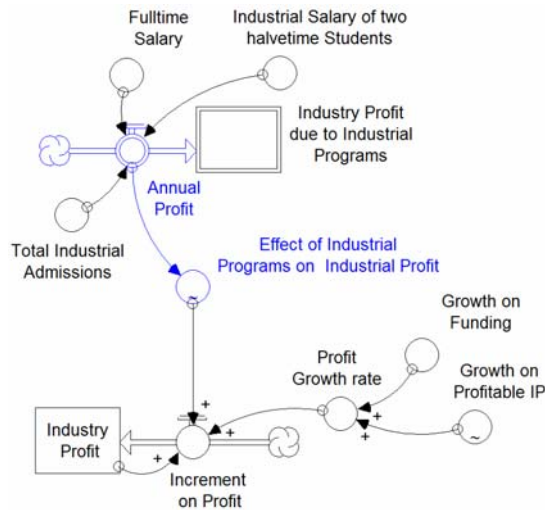
Figure 87: The effect of profit due to industrial programs on the Industry Profit: University-Industry cooperation model.

The industrial profit also increases the interest on collaboration as seen on figures 53, 57 and 88. If the government compensates the university with the taxes charged to industry per Industrial Student, this is about 20.000,00 NOK (University Profit per student), this money can also create a greater collaboration of the university on R&D with industry. Figure 88 portrays such structure.
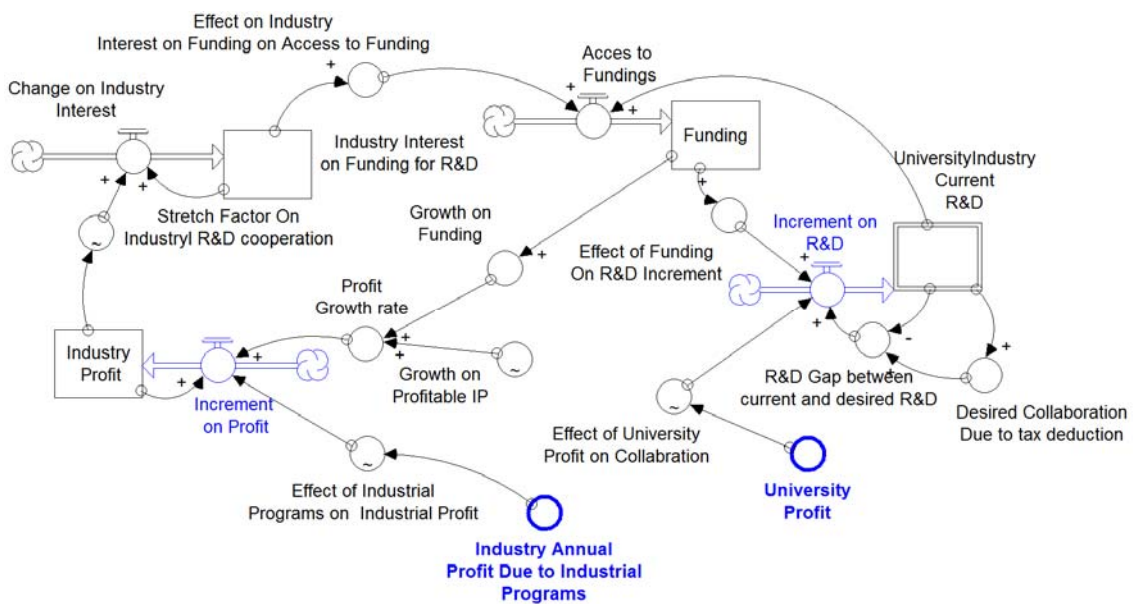
Figure 88: SFD of the University-Industry collaboration and the new industrial programs policy

Simulated Benefits of the Industrial Programs' Policy:

As expected, the Industrial programs dramatically reduce the total need of skilled workers in Norway; the admission to industrial programs is a function of such need. Figure 89 compare the effect of discussed policies on the total need of skilled workers.

Figure 89: Total Need of Skilled Workers: 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion; 4) Including Industrial University Programs

Industrial students are seen as junior workers in our modeling process, therefore is very likely that Jr workers (industrial Students) are hired as senior workers after graduation. Figure 90 compare the other policies effect on the ratio employed GT-to-GT emigrated. It is observed that Both, DAMVAD's policy and Industrial Programs' proposal dramatically increase such ratio, which represents a higher employment among GT and less emigration. In other word, we increase opportunities for them to stay and power the labor market.

Figure 90: Employed GT-to-GT Emigrated: 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion; 4) Including Industrial University Programs

Figure 91 is the simulation of the stock and flow diagram portrayed on figure 86. It show the amount on millions of Norwegian coroners saved by industry when supporting Industrial Students (workers), and the amount of millions of Norwegian coroners obtained by the university if the Government would cede the taxes charged per student to the university. This corresponds to about twenty thousand per student.
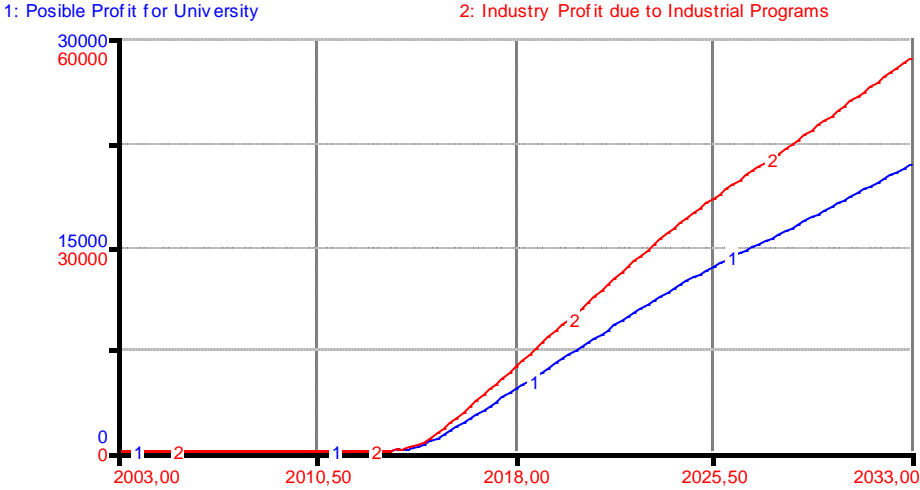
Figure 91: Profit in millions of Norwegian coroners for both: Industry and University

Ceding the taxes to the university may also have a stronger impact on the university-industry R&D collaboration, see figure 92. The relationship is found on the SFD on figure 88. There is a gross increment on collaboration with consequently lead to increase the performance of TTO's and perhaps creates more profitable IP as discussed in section 3.4 figure 57.
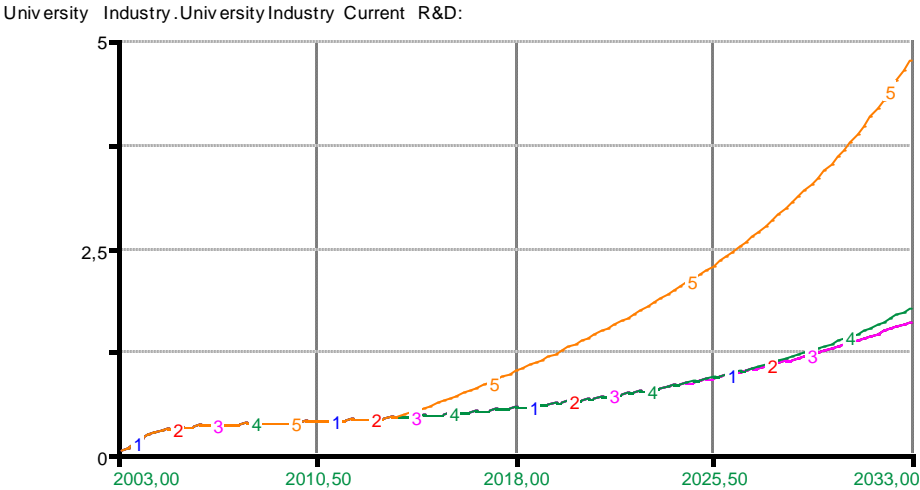
Figure 92: University-Industry Collaboration: 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion; 4) Including Industrial University Programs; 5) allowing University to get the taxes charged to Industry per Industrial student.

Simulated Cost of the Industrial Programs' Policy:

So far we have pointed out some of the benefits of including industrial programs to the current university-Industry collaboration types, but it is important to test negative effects of the policy. When it comes to monetary cost, we have proven there is no real cost, but rather profit for all entities: university, industry, and perhaps for the Norwegian government (less Lånekasse). On the other hand, we evaluate the price in terms of workers' productivity; the more juniors the less the productivity as discussed on section 4.5 and figure 80.

The results are shown on figure 94. Figure 93 portrays a structure to test the total workers' productivity. This models is similar to the model portrayed on figure 80, however, the SFD on figure 93 includes a more completed analysis; it counts the Norwegian workers too.
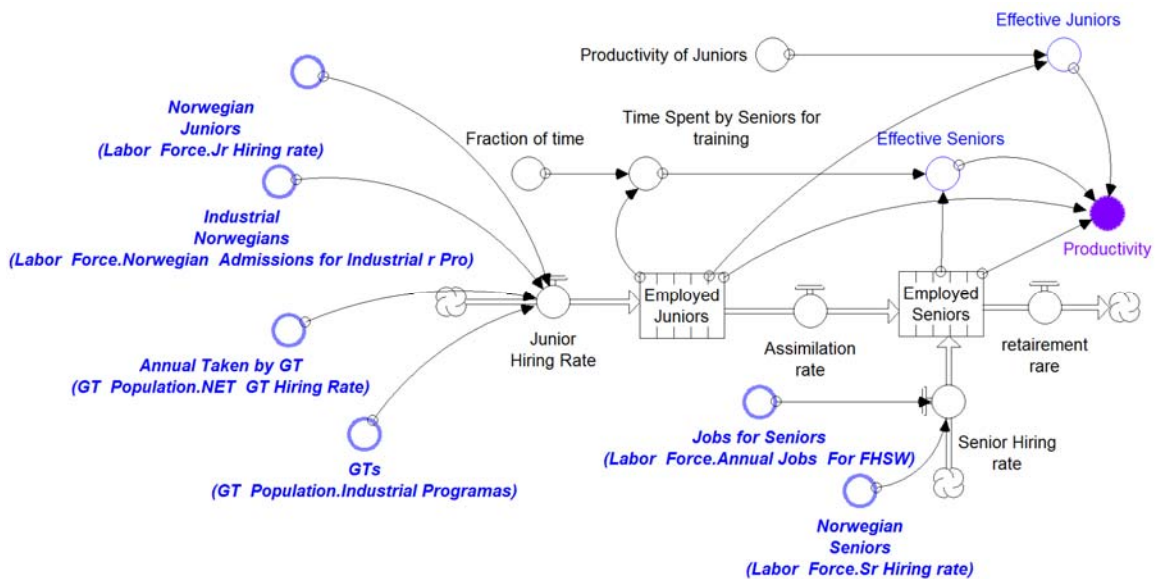
Figure 93: Measuring Workers' Productivity: Including Norwegians and Internationals

A significant decrement on productivity, given by the time experienced workers would have to spend teaching juniors about their job, can be initially observed. However as the first generation of juniors become seniors, the productivity recoveries and starting growing.
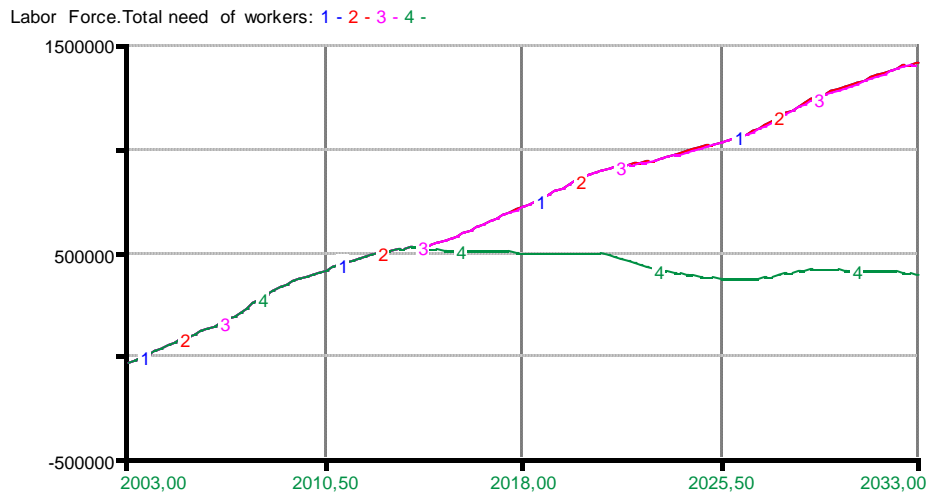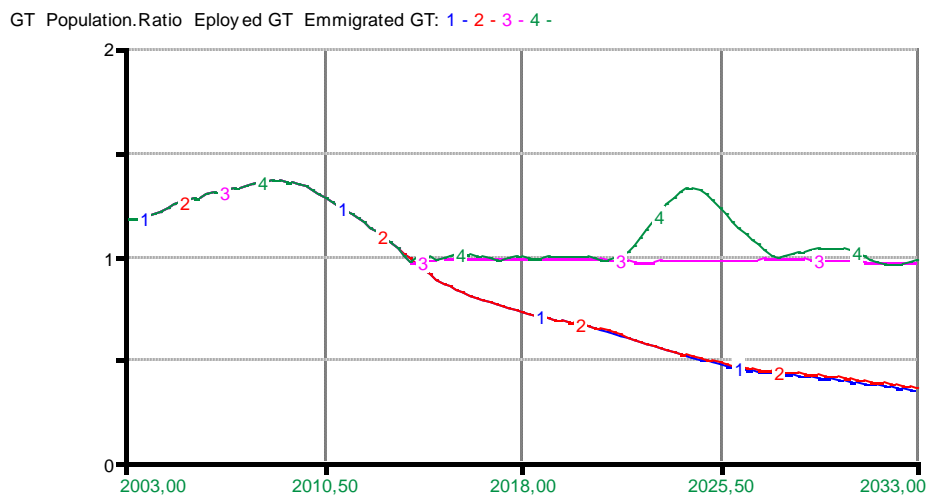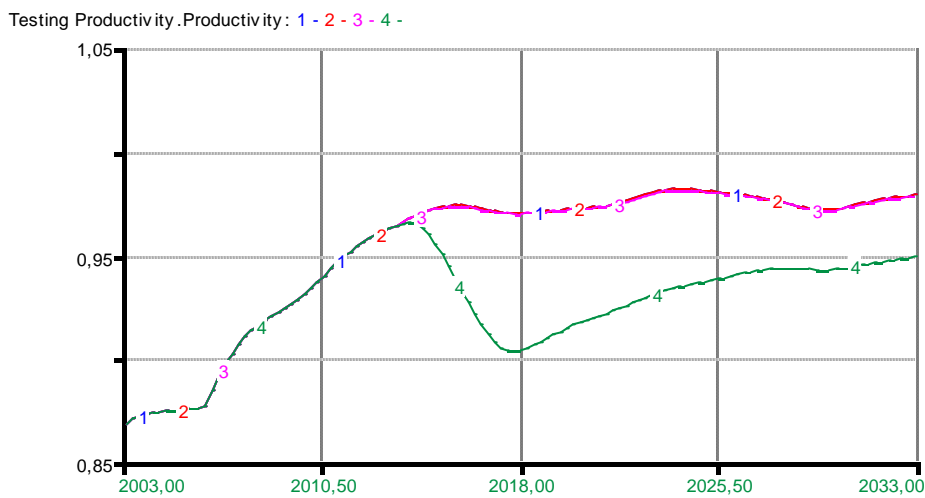

Figure 94: Total Workers productivity: 1) Current dynamics; 2) Controlling University Admissions; 3) Adding DAMVAD's suggestion; 4) Including Industrial University Programs;

Chapter V:

Discussing implementation:

In general, communication in and between organizations is a complex and difficult process. When transmitting messages at lower levels of an organization, communicators distort. For successful implementation, it is necessary institutional processes that allow subordinates act according to objectives of policy; the communication entity organizations and activities to force action [43].

5.1 The strategy of implementation process:

Without a doubt, the most important step to understand the problematic and its possible solutions, it is necessary to retake the influential essay "Implementation Game" of Bardach [42], who drew a distinction between the implementation problem and the implementation process. The first term is referred to control and management of activities, and the implementation process is a something very terribly frustrating, tedious, and makes enemies.

Bardach describes the implementation process similar to a machine's assembly process and its components, which are among others: financial resources, administration, funding, public and private institutions, and support groups. Thus the implementation is assembly procedures of different elements of the policy program which are in the hands of different entities in depend to each other, wherefore persuasion and negotiation are the only way to achieve each independent organization cooperates providing the elements of the policy program which are within its reach and control.

Only if the suggested policy or program is highly defensive, its implementation process can be no longer in any way politicized, since the existence of a well-defined political mandate, which has been legally authorized in a previous stage of the political process, determinates the strategy and tactics of fighting.

In addition, Bardach suggests another metaphor that of "Games", understood as strategies and techniques of interaction trough which it comes into interaction independent actors, possessing various resources of the program or policy seen as necessary components for producing the desired event or goal. So the implementation process is characterized by the maneuvering of many semi-autonomous actors, each of which tries to access the elements of the program and keep them under their control, while trying to extract the best advantages of other players also looking to access elements that give them control.

The negative effects of the game of implementation are:

1. Diverting resources, especially money, which should be used to create or obtain certain program elements.
2. Distortion policy objective stipulated in the original mandate.
3. Resistance to efforts to explicitly and institutionalized manner, are carried out in order to achieve administrative control of behavior.
4. Dissipation of personal energies and policies by playing games that would have been better channeled into constructive action program.

To prevent clogging by actors who hold a monopoly on the key elements of a program, Bardach proposed:

- Dispense with them, developing and designing a program that does not include the monopoly elements.
- Create a new monopoly that is or becomes subject to Allied control.
- Promote competition.
- Bribe and co-opt them
- Create balance, trough the creation or promoting of organization able to press or watch the monopolist of economic and political market.

To prevent clogging from massive resistance:

a) Prescription. Orders clear and noticeable, whose effects may be increased in enjoyment as supporting authority, influence, coactivity.
b) Enabling. Provide resources that an actor desires and lacks, and influences it to deliver its contributions to the collective action program.
c) Incentive
d) Dissuasion

Three methods to speed up the assembly process, reducing cost and delays are:

1. Prioritizing. Almost common sense, but in the project's design and implementation, priorities are easily forgotten.
2. Contrive. Promote capacity, derived from the knowledge and experience, to find solutions on the status of the problem and needs.
3. Project Management techniques. Manage the actors.

5.2 Industrial University Program policy:

Our suggested policy basically consists on the creation of free-tuitions industrial programs for both Norwegian and International Students at all university levels but especially master programs. We propone a 3 year-industrial program which would entitle graduates with a master program and 3 years of work experience, so students can be considered as senior upon graduation.

We have suggested that education in Norway should remain free of cost, an enormous possibility for industry to make profit of such industrial programs, the possibility for the university to increase popularity, internationalization, and its teaching, the possibility that the government transfer taxes charged to the industrial program salaries to the university, meet the need of high skilled workers, optimize the investment on global talent when offering them free education, and finally the government could spare the money assigned to the Norwegian student's loans. But the most important and priority here are not only Global talent but any University student; they are the most important outcome not only of the universities but also of a knowledge-based economy.

The negative effects of the game of the Industrial University programs are:

1. Diverting resources, in the case of the University, of the money obtained from the government due to the taxation to salaries. The money should be used to either hiring more teaching personnel or to increase the Norwegian language courses that should be compulsory for any student of its own convenience and integration to the host culture.
2. Distortion policy objective: the objective is investing in the knowledge of university students and the program must not be seen as profitable business from the Industry to get cheap labor force. There must be a compromise from industry to care of the students and see students as most important outcome.
3. Resistance from the government to allow industry pays a significant less amount of salary for to halve time students instead of a fulltime employ. The Government most see this policy as if the industry would loan money to the students and interests are paid with lower salaries but salaries that are fair and equally than a salary that none qualifies jobs could proportionate to the students.

4. Dissipation of personal energies and policies: Government, industry and University most understand that all of them would benefit from the industrial programs.

To prevent clogging by the government who hold a monopoly in terms of the education, funding and taxes. The key elements of a program are:

- Industrial Programs do not represent expenditure for the government in terms of funding, or taxation, or changing constitutional laws. But rather playing with rules to make the most of tertiary students.
- We are creating a new monopoly called: Industrial Programs that is or becomes subject to Allied control between the government, industry and university.
- Promote competition: among industry, startups and local companies must be prioritized to participate in the program rather than big corporations.
- Create an alliance institution able to press or watch all parties to act within the objective of the program.

To prevent clogging from massive resistance to the industrial programs:

a) The cooperation, and role between university, industry must be very clear. University programs most not benefit all industrial needs, and the university should keep autonomous in the research line. Industry most support student taking program that already exist in the university curricula and that closely matches their need. Some combined programs can be designed in the case of CRIs.

b) Enabling. We provide Industry with the labor it needs, but it most cooperate by supporting university's existing programs rather than trying to residing curricula. University will be provided with extra funds, but it should be also more selective when admitting new students to match the student's professional profile to industry need.

c) Incentive: both university and industry would have economic incentive of such programs as shown in previous section.

d) Dissuasion by showing all entities the pros, and how coins may be seen and used to strength the program. In our case the slightly productivity decrement over the first years of the implementation, however productivity will recover within a very short time; benefits are having more seniors.

Three methods to speed up the assembly process, reducing cost and delays are:

1. Prioritizing. Students must be our priority, they most feel welcome, happy, and enjoying being part of such integrative program. Global Talent most also feel welcome in a host culture because they are the complement of the Norwegian labor force.
2. Contrive. Promote capacity of both industry and university in terms of research.
3. Project Management techniques. A new institution should be created to manage and supervise all parties involved: Students, University, industry, and government.

Appendix A:

Graduates outflow per academic year	University Graduate Students:									
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GT Graduated	1867	2006	2199	2531	2984	2985	3217	3143	3442	4060
Total	30809	33579	32181	33650	37524	35355	36031	38004	40568	40486
NGT Graduated	28942	31573	29982	31119	34540	32370	32814	34861	37126	36426
http://www.ssb.no/en/eksuvh/										

JOB VACANCIES								
	2006	2007	2008	2009	2010	2011	2012	2 013
Public:								
Undervisning	22 942	28 940	28 551	27 141	24 120	23 615	23 964	22 681
Helse	53 863	63 234	61 108	52 647	45 805	47 082	48 926	49 252
Andre	2 618	2 446	2 548	2 718	2 048	2 043	2 352	2 438
Total:	79 423	94 620	92 207	82 506	71 973	72 740	75 242	74 371
	2006	2007	2008	2009	2010	2011	2012	2 013
Private:								
Ledere	11 946	15 392	15 165	10 974	11 054	12 366	3 387	3 364
Engeenering	28 023	34 056	31 479	18 866	18 925	24 470	24 933	19 012
Konsulenter	20 198	24 428	23 123	14 532	14 057	13 512	8 623	6 958
Andre	11 159	12 743	11 172	5 835	5 530	6 655	7 823	5 498
Akademia:	14 902	18 253	19 167	14 872	13 946	14 690	12 884	12 209
Total:	71 326	86 619	80 939	50 207	49 566	57 003	57 650	47 041

Stock per academic year	Total Registrered Students at Norwegian Universities and collages										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total	191582	194079	194976	193431	190069	193256	201601	207022	217939	226852	232726
International Students	8104	9302	10225	10829	11487	12058	12200	14560	14786	15974	17856
Exchange Students	0	0	0	8953	9095	9850	10763	12020	12591	13201	8838
Norwegian Students	183478	184777	184751	173649	169487	171348	178638	180442	190562	197677	206032
http://dbh.nsd.uib.no/statistikk/kategori_studenter.action;jsessionid=8A3783DDC8C53639360B62CFE6559A21											

Appendix B:

Based on [12-15].

Introduction to Structural models, power law, and elasticity

B.1) Introduction to Structural Models:

Structural modeling means that we do not aim at making metaphysical claims about causal relations, but rather at saying when we have enough reasons –specifically, reasons about our background knowledge and about structural stability – to believe that we hit upon a causal relation. Both background knowledge and stability must be involved.

It is important to remember some basic probability concepts: Given two variables X and Y, the marginal probability P_X and P_Z gives the probability of values of the variables in the subset without reference to the values of the other variable; this differs to the conditional probability $P_{Y|X}$, which gives the probabilities contingent upon the values of the other variables.

In structural equation models, the basic idea is that given a system of equations, we can test whether variables are interrelated trough a set of linear relationships. In other words, we conditionate the model. Let's start by looking at an unconditional statistical model:

$$M\,_X^\omega = \{ P_X(x|\omega) : \omega \in \Omega \}$$

(B.1)

$P_X(x|\omega)$ Is the probability density (sampling) on an underlying sample space corresponding to a random variable X, and Ω is the parameter space for each ω of interest. By decomposing the vector X into X'= (Y', Z') (where ' denotes transposition), the model is conditional on Z. The basic idea of a conditional model starts from the global model described on eq. B.1 and each sampling density $P_X(x|\omega)$ is first decomposed trough a marginal-conditional product:

$$P_X(x|\omega) = P_Z(z|\phi)P_{Y|Z}(y|z,\theta) \; : \; \omega = (\phi, \theta)$$

(B.2)

Where $P_Z(z|\phi)$ is the marginal density of Z, parameterized by ϕ, and $P_{Y|Z}(y|z,\theta)$ is the conditional density of$(Y|Z)$, parameterized byθ. Next, one makes specific assumptions on the conditional component leaving virtually unspecified the marginal component. The conditional Model is represented as follow:

$$M\,_X^{Z,\theta;\Phi} = \left\{ P_X(x|\omega) = P_Z(z|\phi)P_{Y|Z}(y|z,\theta) \; : \; \omega = (\phi,\theta) \in \Omega = \Theta \times \Phi \right\}$$

(B.3)

Φ represents a subset of set of all probability distributions of Z and its role is to stress the random character of Z.

To exemplify a structural conditional model consider four variables: tabacism (T), cancer of the respiratory system (C), asbestos exposure (A) and socio-economic status (SES). An unconditional model would consider the a family of distributions on the four variables (T, C, A, SES) parameterized by, say,ω, as in (B.1) . On the other hand, a conditional approach would consider the effect of T, A, and SES on C. Attention would focus on a particular component of the global model, namely the conditional distribution of C given T, A, and SES, leaving the marginal distribution of T, A, and SES

with the minimum amount of specifications. The marginal –conditional decomposition would then be:

$$P_{C,T,A,SES}(c,t,a,ses|\omega) = P_{(C|T,A,SES)}(c|t,a,ses,\theta)\, P_{T,A,SES}(t,a,ses|\phi) \qquad \text{(B.4)}$$

The basic Idea of such model is to endow the global model in equation B.1 with two properties: 1) the parameters characterizing the marginal ϕ and the conditional θ components are independent meaning "variation-free" in the sampling theory framework, or (prior) probability in Bayesian framework. 2) The marginal term is left almost unspecified, representing a very large of possible set of distributions for (T, A, SES).

Exogeneity for Conditional Models:

Suppose that analyzing the data set X = (Y, Z), the challenge is to decide whether it is admissible, in sense of not losing relevant information, to only specify a conditional model $M\,{}^{Z,\theta;\Phi}_{X}$ rather than specifying the unconditional model $M\,{}^{\omega}_{X}$. This is an Exogeneity issue.

By using the conditional instead of the unconditional models, some specification on the marginal process may not be avoided for ensuring suitable properties of the inference on the parameters of the conditional process but by specifying less stringently the marginal process, generating Z, one looks for protection against specification error. The condition of exogeniety is that the parameter of interest should not only depend on the parameters identified by the conditional model, and the parameter identified by the marginal process should be "independent" of the parameter identified by the conditional process.

Exogeneity in a structural conditional model [Z]: It is defined, in a very simple case of two variables Y and Z, if the conditional distribution of Y given Z is structurally stable and reflects a good scientific knowledge of the field, there is no reason to not believe that Z causes Y. This approach might be consider as empirical because the observations providing the ground for causal interpretation are not only the data under immediate analysis but also the whole body of observations underlying the "Field of Knowledge" and leading accordingly to the present state of scientific knowledge.

Controlling Confounding bias:

In many circumstance the same effect can be produced by several causes or the same cause can produce several factors. In other words there exist confounders. A cofounder or cofounding variable is a variable which is a common cause of both the putative cause and its outcome.
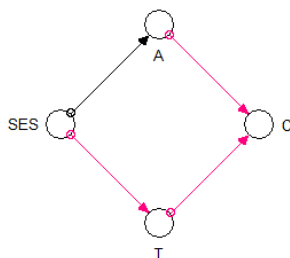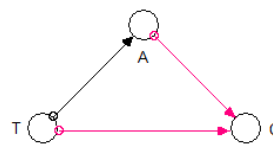

Figure B.1

Figure B.2

Retaking the example of tabacism, SES on figure B1, and T on B2 are cofounding parameters. In figure B.2, A is a common cause of both T and C, but this is no longer true on figure B.1. The problem with the present of cofounding bias on structural models provokes skepticism, but in modern causal thinking, there are many methods for controlling confounders like the back-door and front-door approach [12, 13]. Whenever we undertake to evaluate the effect of one factor (X) on another (Y), the question arises as to whether we should adjust our measurement for possible variation in some other factors (Z), otherwise confounders. Adjustment extents to partitioning the population into groups that are homogenous relative to Z, assessing the effect of X on Y in each homogenous group, and then averaging the results. Any statistical relationship between two variables may be reversed by including additional factors in the analysis. For example, we may find that students who smoke obtain better grades than non-smoking students but, adjusting for age, smokers get lower grades than non-smokers, additional adjusting for family income, smokers again obtain higher grades than those student who do not smoke in every income-age group, and so on.

Then the question is open: What criterion should one use to decide which variables are appropriate for adjustment? The back-door approach presents a formal solution of adjustment using causal graphs.

Assume we are given a causal diagram G, as the portrayed on figure B.3, together with non-experimental data on a subset V = {a1...5} of observed variables on the diagram G. We wish to estimate what effect the interventions on V would have on Y. in other words we seek to estimate $P(y|\hat{x})$ from a sample of P(v). The back-door criterion can be applied directly to the causal diagram in order to test if a set $Z \subseteq V$ of variables is sufficient for identifying $P(y|\hat{x})$.

Figure B.3
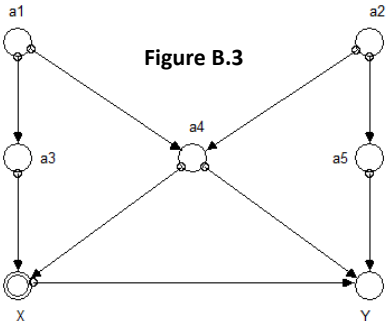
BACK-DOOR Definition: A set of variables Z satisfies the back-door criterion relative to an ordered pair of variables (X,Y) in a Causal diagram (For example B.3) if:

1) No node in Z is a descendant of X; and
2) Z blocks every path between X and Y that contains an arrow into X.

Similarly, if X_i and Y_i are two disjoint subset of nodes in G, then Z is said to satisfy the back-door criterion relative to (X_i Y_i) if it satisfies the criterion relative to any pair (X,Y) such that $X \in X_i$ and $Y \in Y_i$.

Now using the same figure B.3, we test the effect of the subsets: $Z_1 = \{a_3, a_4\}$, $Z_2 = \{a_5, a_4\}$, and $Z_3 = \{a_4\}$ on Y given X. Z_1 and Z_2 meet the back-door criterion, but Z_3 does not because a_4 does not block the path $(X, a_{3,} a_{1,} a_{4,} a_{2,} a_{5,} Y)$.

Theorem: If a set of variables Z satisfies the back-door criterion relative to (X, Y), then the causal effect of X on Y is identifiable and is given by the next formula:

$$P(y|\hat{x}) = \sum_Z P(y|x, z)P(z) \qquad\qquad (B.5)$$

B.2) Introduction Elasticity and the Power law:

The power law or scaling law is the great interest inside and outside economics, it has proven useful regularities in social sciences [14, 15]. In this section we will use the power law to develop the elasticity law used in economics and to understand and prove how the power law can be applied to model to variables. Let's assume we want to quantify the effect of an independent variable X on a dependent variable Y, the power law approximates Y as an exponential scaled function of X as described on equation B.6 where k is the scaling factor typically constant, and α is the power coefficient.

$$Y = kX^{\alpha} \tag{B.6}$$

To exemplify the potential use of the power law, let's use figure B.4. On the left side we have two independent variables X and Z. X is a linear equation while Z is concave function. The power formula B.6 could be applied to estimate Z using the approximate function Y. On the right of the same figure we have computed Y for different values α and but being k=1 for all computation.
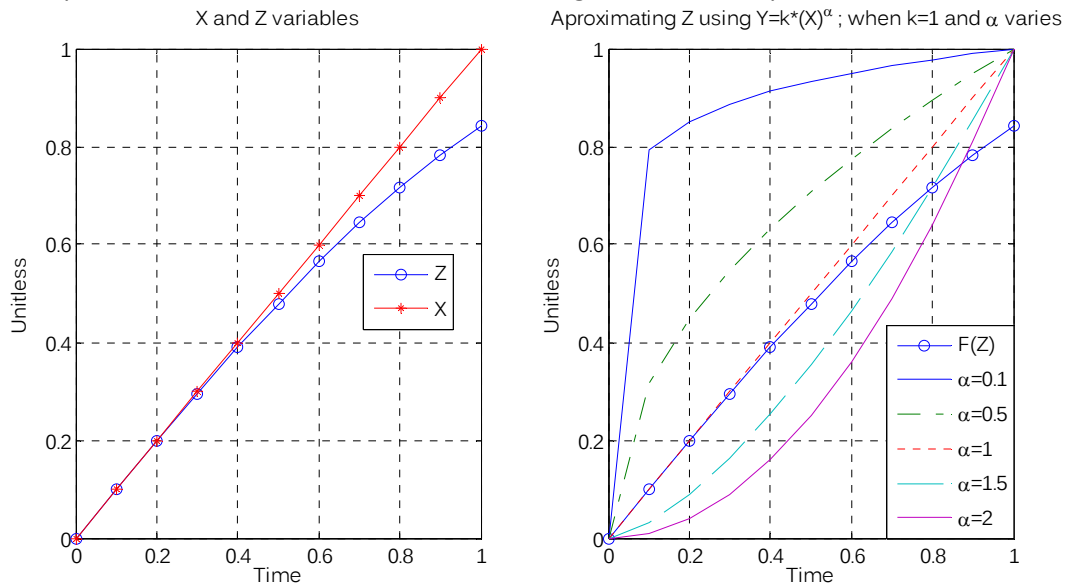
Figure B.4: The use of the power law. See equation B.6

Looking at the right side of the figure B.4, as expected Y = X when both $\alpha = k = 1$. As we varies the values of α, Y becomes either convex (α >1) or concave (α <1). On the picture the best approximation is given by $\alpha = 0.5$ due to its concave shape, but the amplitude level much higher meaning we need to scale Y by decreasing k. see figure B.5.

Figure B.5: The use of power low when scaling the factor k.

We can infer, by optimizing both the power coefficient and the scaling factor of the power law equation, it is possible to approximate any function. Complex functions require a more expanded version of the power law [14, 15]. Our next goal is to derivate the elasticity formula on economics for the price and demand from the powe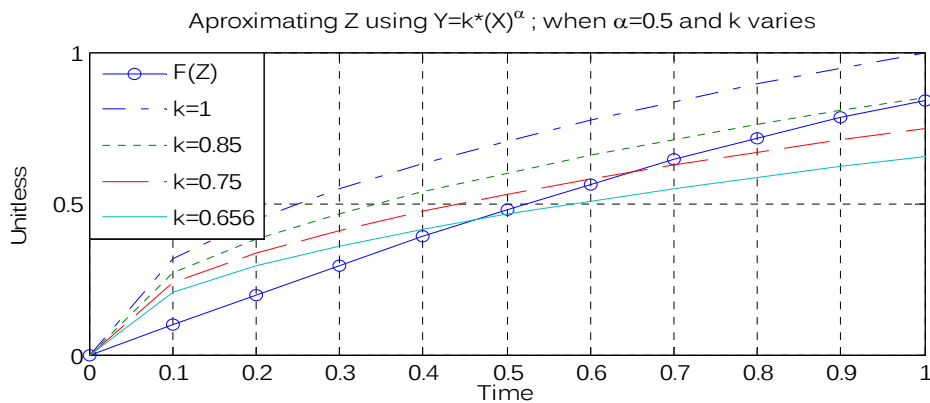r law equation and finally demonstrated how the power or elasticity equation can be applied to our system dynamics model.

We know that the elasticity coefficient ε of the price-demand of a given commercial product is given by division of both: the change in price and the change in demand.

$$\varepsilon = \frac{\Delta Price}{\Delta Demand} = \left| \frac{Price}{Demand} \frac{\Delta Demand}{\Delta Price} \right| \qquad\qquad \text{B.7}$$

Now let's assume that we want to predict the _effect of demand on price_ of a given product, in our store, based on the elasticity factor of the same product over the last two weeks. We first compute the elasticity using formula B.7, then we try comparing both changes on price and demand, over the two weeks and assume a linear relationship, i.e. $\varepsilon = 1$.

$$\frac{Price_{week1}}{Price_{week2}} = \left[\frac{Demand_{week1}}{Demand_{week2}} \right]^{\varepsilon=1} \qquad\qquad \text{B.8}$$

This interactive scaling relationship results on the power law and can be rearranged as:

$$Price = \left[\frac{Price_{week1}}{Demand_{week1}{}^{\varepsilon}} \right] Y^{\varepsilon} = kY^{\varepsilon} \qquad\qquad \text{B.9}$$

Now we find that the elasticity coefficient ε is also a power coefficient α which is used to estimate the effect of one variable on another as discussed previously. Using the same analogy and theory, on figure 12 of our thesis work, we compute for instance the effect of Norwegian courses on cultural adaptation of global talent (international graduate students) as:

$$Effec\_Norw\_on\_Cultural\_adap = Norwegian\_Courses^{\varepsilon\_Norwegian\_Courses} \qquad \text{B.10}$$

Where it is assume a unit scaling facto k, and the elasticity is the change on the students opinion on whether to take Norwegian language courses is or not important on their daily cultural adaptation process. The elasticity factor is as a weigh.

Appendix C:

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Sendt: 27. februar 2013 16:59
Til: webskjema
Emne: reply from udi

Fornavn_og_mellomnavn: Francisco

Etternavn: Mainou

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Fritekstsfelt: Good Day

I am participating on a project plan for a start-up company. We would like to get advice from UDI concerning the Next:

As Start-up Company, we would like to hire two bachelor engineers to work on a prototype both of them in 50% (no more than 20 hrs. a week), and at the same time we would like that our engineers join a specific master degree at NTNU. We know that in order to have a student visa for non-European citizens, UDI ask to self-finance students to have 95000NOK per year in a Bank account, we would like to afford this fee for our 2 engineers while studying and working non full time for us.

Is this possible?

-Basically the plan is to invest in our future Master engineers.

Thanks for your reply

no_reply@udi.no

Dear Francisco,

We refer to your e-mail dated 27th February 2013.

In order to be granted a study permit, it is a requirement that the student can document funds corresponding to 92 500NOK a year. If the student presents a work contract with the application, the income can count towards the income requirement.

Expected income from any part-time or full-time work during holidays can be included in the assessment of whether the subsistence requirement is met. The applicant must present an offer of employment in which the scope of the job and pay per month in NOK is stated.

Please note that for a student who is financing his/her studies through income from employment, the subsistence requirement is NOK 20,000 higher than the full support amount at all times (this is because the income will be taxed). If the foreign national is only partially financing his/her studies by means of income from employment, the funds required above the amount corresponding to full support will be reduced proportionately.

If the applicant has own funds at his/her disposal, for example in addition to income from part time work covering parts of the required amount, the general rule is that the applicant must transfer the amount to an account in a Norwegian bank in his/her own name. Alternatively, the applicant can deposit the amount in an account that the educational institution has opened for this purpose or in a country.

As a rule, third-party guarantees are not accepted. This applies regardless of whether the guarantor is in Norway or elsewhere. Consequently, you cannot guarantee for the students by providing any kind of guarantee letter or means on the company's account.

Third-party guarantees for accommodation can however be accepted. If a third party is to guarantee accommodation, it is a condition that a lease between the parties is presented in which it is stated that the applicant will not pay rent.

The value of the housing/lodgings will be set at half the value of board and lodging corresponding to 2000 NOK per month. The 2000 NOK can then be deducted from the 92.500 NOK.

Best regards

Hege Øye Berg

Executive Officer, The Service Unit

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